December, 1976
Price, $2.00

The Prospect for Fusion Power

Sonar Search for the Loch Ness Monster

Common Sense about Engineering

K S FILE COPY

Technology Review

Edited at the Massachusetts Institute of Technology

technology
review
Published by MIT

This PDF is for your personal, non-commercial use only.
Distribution and use of this material are governed by copyright law.
For non-personal use, or to order multiple copies please email
permissions@technologyreview.com.

Hear the light.

Today, communications may be at the threshold of another revolution in technology.

Someday soon, when you make a phone call, your voice may be carried between telephone offices as pulses of light over a hair-thin glass fiber.

We call this new technology lightwave communications.

Less Cost, Less Space:

Lightwave communications has the potential for carrying enormous quantities of information—from phone calls to business data to TV programs—at low cost. And it can do it in much less space.

Right now, we're testing an experimental system that can carry nearly 50,000 phone calls in a cable of glass fibers not much thicker than a clothesline. It could do the work of several copper cables, each as thick as your arm.

That will allow us to save space in the crowded cable ducts under the streets of many of our cities. Which in turn will lessen the need to add new cable ducts to expand service.

But even carrying that many calls uses only a fraction of a light beam's capacity.

So it will give us plenty of room to grow.

To make lightwave communications possible, the people at Bell Labs and Western Electric attacked a number of problems simultaneously.

What Had to be Done:

What kind of problems?

Creating some of the most transparent glass the world has ever known.

Developing techniques to draw the glass into highly precise fibers which, despite their tiny size, have a complex internal structure that keeps the light from leaking out.

Devising ways to protect the delicate fibers from damage, to make them into cables strong enough to pull through underground ducts, and to splice them—a hundred or more at a time.

To generate the light carried by the fibers, they developed a tiny, solid-state laser smaller than a grain of salt. (Today's design is expected to operate continuously for ten years or more.)

To put information onto the light beam, they designed equipment that turns the tiny laser on and off millions of times a second.

And they developed repeaters to regenerate the light signal along its way, as well as photodetectors at the receiving end to convert the light back into an electrical signal that can travel throughout the telephone network.

We think lightwave communications may prove a long step forward in the development of communications.

We may put it to use in the early 1980's to relieve cable congestion between major switching centers. For special applications, we may use it even sooner.

And it may someday carry business data, visual communication services and facsimile transmission into your home and office.

Seeing to It:

Innovations from Bell Labs and Western Electric are put to work by your Bell telephone company. That's another reason you have the most reliable, least expensive telephone service in the world.

To keep it that way, one of the things we're doing is seeing to it that before long you'll be hearing the light.

One of a series of messages to keep you informed of how telecommunications technology is changing our world—and the part Bell Labs, Western Electric and your Bell telephone company are playing in it.

Bell Laboratories/Western Electric

Edited at the
Massachusetts Institute of Technology

Volume 79, Number 2
December, 1976

Technology Review

Technology Review, Reg. U.S. Patent Office is published eight times each year (in October/November, December, January, February, March/April, May, June and July/August) at the Massachusetts Institute of Technology: two special editions are provided for graduate (pp. A1-A52) and undergraduate (pp. A1-A52, and B1-B24) alumni of M.I.T. Entire contents copyright 1976 by the Alumni Association of the Massachusetts Institute of Technology. Technology Review is printed by The Lane Press, Inc., Burlington, Vt. Second class postage paid at Boston, Mass., and at additional mailing offices.

Inquiries regarding editorial contents, subscriptions and advertising should be addressed to: Technology Review, Room E19-430, Massachusetts Institute of Technology, Cambridge Mass., 02139. Telephone area code (617) 253-4872.

Price: $2 per copy. Subscriptions: in the U.S., Canada, and Mexico — $15 one year, $24 two years, $32 three years; overseas $23 one year, $38 two years, $50 three years. Please allow three weeks for changes of address and give both old and new addresses in all requests.

Technology Review is represented for advertising by: Littell-Murray-Barnhill, Inc., 60 E. 42nd Street, New York, N.Y., 10017, telephone (212) 867-3660; Cemcon, 4 N. Elmhurst Street, Prospect Heights, Ill., telephone (312) 398-0794; Zander, Coughlin and Bigler, 5478 Wilshire Boulevard, Los Angeles, Calif., 90036, telephone (213) 938-0111 and 22 Battery Street, San Francisco, Calif., 94111, telephone (415) 398-4444.

Publisher
James A. Champy

Board of Editors
John I. Mattill *(Editor)*, Dennis L. Meredith, Michael Feirtag, Sara Jane Neustadtl, Marjorie Lyon, Deborah McGill, Susanne Fairclough

Production
Kathleen B. Sayre

Advertising
Richard F. Wright

Circulation
Katherine A. Potter

Subscription Service
Dorothy R. Finnerty

Articles

Departments

Letters

Riposte

Once again there is "nothing new under the sun" — or the stars. Jerome Lettvin writes that "Plato tells us that the gods are stars, and he does not claim to have invented the idea" *("The Use of Myth," June, pp. 52-57).*

Now, 24 centuries later, we have the latter-day version of the same fantasy in Frank Drake's "immortals" *("On Hands and Knees in Search of Elysium," June, pp. 22-29).* They reside in distant galaxies and can tell us "ways to improve the quality of life on earth at an unprecedented rate" and "the way of life most likely to be best for us in the long run."

The ancients sacrificed much, even lives, to "communicate" with their gods. We are asked for only $10 billion. When do we learn that we must find our way on our own, with maturity and self-respect?

Robert L. Sinsheimer
Pasadena, Calif.

Dr. Sinsheimer is Chairman of the Division of Biology at California Institute of Technology. — Ed.

No Carcinogens Added

"Prudence, Profit, and Cancer: A Fierce Tug of War" (May, pp. 16-18), speaks of ". . . the continued use of other proven carcinogens as food additives."

This statement is false; there are no food additives currently in use which have been proven carcinogenic. The Delaney Clause in the 1958 amendments to the Food, Drug and Cosmetic Act specifically prohibits such additives, and the Food and Drug Administration is very sensitive to such matters. Even the much publicized cyclamates and the dye Red No. 2 have not been proven carcinogenic. Certain questions concerning their "generally-regarded-as-safe" status have not been adequately answered, which is the basis for their removal from the food supply. If and when these questions are satisfactorily answered, these ingredients could once again be allowed in foods.

Such statements have been popularized by the "natural is good; artificial is bad" advocates and others, but the allegations are not supported by scientifically verified facts.

Norman E. Bednarcyk
Fair lawn, N.J.

Dr. Bednarcyk is Manager of Science Services for Nabisco, Inc.— Ed.

Cancer and the Quality of Life

"Prudence, Profit, and Cancer: A Fierce Tug of War" *(May, pp. 16-18)* contains several generalizations and implications that are not warranted by the facts. The report (by Sara Jane Neustadtl of the *Review* staff) quotes statements and cites opinions of three persons, Samuel Epstein, Barry Commoner, and Nicholas Ashford, employed by academic institutions and one person, Roger Drexel, employed by an industrial corporation.

One paragraph in the report begins, "Says industry . . ." and the next paragraph begins, "Say environmentalists . . ." I was involved in establishing an Environmental Hygiene and Toxicology Department in an industrial corporation in 1962; I directed the department until April, 1976. I do not know whether you would quote me as an industrial environmentalist or an environmental industrialist.

The question is not "Should the tendency to induce tumors be sufficient evidence for a substance to be classified as a possible carcinogen, and thus regulated?" Tumorogenicity or carcinogenicity are not the only toxic effects that require regulation. There are regulations pertaining to the workplace, air pollution, water pollution, solid waste disposal, and transportation of substances. The real question is what form of additional regulations will provide additional protection against possible risks at a cost that bears some relationship to the protection provided.

The question is not "Can the results of experiments on mice and rats be extrapolated to man?" Neither the mouse nor the rat are always the best choice of experimental animal. If industry does not believe that experiments with rats and mice have any validity, then industry is spending millions of dollars in tests that they believe are without value. The eye kept on profit must have seriously impaired vision to commit such vast sums in a valueless effort. The real question is the proper design and interpretation of the test procedures.

Dr. Epstein is quoted, "Before you introduce substances into the environment, test to make sure they don't harm the environment or humans." This could be construed to mean that any new substance should be tested for effects on all existing species in all environments; some of the proposed legislation would have made it possible for the Administrator of the Environmental Protection Agency to specify such a test program.

Ms. Neustadtl states: "Industry feels no obligation to assume responsibility for the public health outside the workplace (as exemplified by the dumping of asbestos fibers into Lake Superior, the dumping of PCBs into the Hudson River, and the continued use of other proven carcinogens as food addititives)." Industry has invested extensively in equipment and facilities for control of air and water pollution. The cost of such control is a part of the cost consumers pay for the products. Some of the investment was made before the enactment of clean air and clean water legislation of the last decade; the rate of investment has changed

STATEMENT OF OWNERSHIP, MANAGEMENT, AND CIRCULATION (Required by 39 U.S.C. 3685)

1. *Title of Publication:* Technology Review
2. *Date of filing:* October 27, 1976
3. *Frequency of issue:* Eight issues/yr.
4. *Location of known office of publication (not printers):* Room E19-430, Massachusetts Institute of Technology, Cambridge, MA, 02139
5. *Location of the headquarters or general business offices of the publishers (not printers):* Same as above
6. *Names and addresses of Publisher, Editor, and Managing Editor:* Publisher: James A. Champy, M.I.T., 7-206, Cambridge, MA, 02139; Editor: John I. Mattill, Room E19-430, M.I.T., Cambridge, MA, 02139; Managing Editor: Dennis Meredith, Room E19-430, M.I.T., Cambridge, MA, 02139
7. *Owner (if owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding 1 per cent or more of the total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a partnership or other unincorporated firm, its name and address, as well as that of each individual, must be given):* Alumni Association of the Massachusetts Institute of Technology, Room E19-437, M.I.T., Cambridge, MA, 02139
8. *Known bondholders, mortgages, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities (if there are none, so state):* None.
9. *For completion by nonprofit organizations authorized to mail at special rates (Section 132.122, Postal Manual): The purpose, function, and nonprofit status of this organization and the exempt status for Federal income tax purposes* – have not changed during the preceding 12 months.
10. *Extent and Nature of circulation:*

	AVERAGE NO. COPIES EACH ISSUE DURING PRECEDING 12 MONTHS	ACTUAL NO. COPIES OF SINGLE ISSUE PUBLISHED NEAREST TO FILING DATE
A. Total number of copies printed (net press run)	56,629	59,104
B. Paid circulation:		
1. Sales through dealers and carriers, street vendors, and counter sales	700	1,075
2. Mail subscriptions	51,130	53,678
Total paid circulation	51,830	54,753
D. Free distribution by mail, carrier or other means, samples, complimentary, and other free copies	885	885
E. Total distribution (sum of C and D)	52,715	55,638
F. Copies not distributed		
1. Office use, leftover, unaccounted, spoiled after printing	3,914	3,466
2. Returns from news agents	0	0
G. Total (sum of E, F1 and 2 – should equal net press run shown in A	56,629	59,104

I certify that the statements made by me above are correct and complete.

Katherine A. Potter, *Circulation Manager*

with the demands of the society within which industry operates.

It is highly probable that Ms. Neustadtl and Drs. Epstein, Commoner, and Ashford all live and work in places that are provided with heat in the cooler months, and all use modes of transportation that discharge carbon monoxide into the environment. Percival Potts demonstrated the relation of scrotal cancer and exposure to the chemicals in soot from fires used for heating more than half a century ago; should we allow even one molecule of chemicals from combustion to heat homes to escape into the environment? Carbon monoxide is known to be fetotoxic; should we allow the generation of any carbon monoxide merely to get from one place to another at a faster rate than we can by walking?

Ms. Neustadtl states: "He [Barry Commoner] thinks manufacture should be limited to those chemicals whose use is irreplaceable." Who is to judge irreplaceability, and what will be the bases of the judgement? Shall we limit our efforts to those necessary only to sustain the life of individuals and the species, or shall we concern ourselves with the quality of the life we sustain? I believe that the majority of the citizens are concerned with the quality of life and not merely a bare subsistence.

Richard Henderson
Bethany, Conn.

Dr. Henderson is Senior Scientist–Health Affairs for Olin Corp. — Ed.

Paying Customers

Samuel Epstein may have muddled rather than clarified the economics of smoking-health research *("The Political and Economic Basis of Cancer," July/August, pp. 34-43).*

Beginning with his assumption — and it is that, no matter how widely held — he suggests that the cost of National Cancer Institute smoking research might be better borne by the tobacco industry. The cost, though Dr. Epstein does not express it, is about $6 million this year. For its part, the tobacco industry, principally through the Council for Tobacco Research (a granting body), is contributing a like amount to independent investigators.

But even this begs the question. As we know, industrial research expenses are ultimately borne by industrial customers. In the case of smokers, they are paying the industry's $6 million health research bill. They are also paying, in the form of direct excises on tobacco products, some $6 billion to public treasuries. That would appear to cover rather well the N.C.I.'s rather modest smoking research expense.

William Kloepfer, Jr.
Washington, D.C.

Dr. Kloepfer is Senior Vice President of the Tobacco Institute, Inc. — Ed.

Faux Pas

The caption to the bar-chart on page 36 of Samuel Epstein's essay *("The Political and Economic Basis of Cancer," July/August, pp. 34-43)* states, "In 1975 alone, five times more people died of cancer than were killed in the Viet Nam and Korean conflicts combined." Counting the cute figures of the little children on this chart, I find that three and a fraction were killed in Viet Nam and Korea together. Again counting, I find that cancer killed 16 minus a small fraction. The implied arithmetic in the caption is inconsistent with the arithmetic of the chart.

Five times three-and-a-fraction must be greater than 15 but less than 20. This is what the bar-chart shows, and it is consistent with the wording, "five times as many." But five times more — as the caption is worded — means precisely six times as many, and is thus inconsistent with the chart.

W. M. Woods
Oak Ridge, Tenn.

Five times as many is correct. — Ed.

The death rate in the country from cancer of 190,000 per 100,000 population shown on page 37 of Samuel Epstein's essay is startling; the fact that we are alive at all is a miracle. It just shows what an exciting age we live in.

Philip Sporn
New York, N.Y.

The scale below the chart is incorrect; each figure represents ten deaths. — Ed.

Loosening the Straightjacket

"Nuclear Power and the Straightjacketed State" *(March/April, pp. 18-19)* documents the constraints on the Massachusetts Commission on Nuclear Safety. But several other states, armed with mandates from progressive state legislatures, are influential in regulating nuclear power.

Notable among them is Oregon. The Oregon Energy Facility Siting Council plays a decisive role in the siting of nuclear power plants. In fact, no large thermal power plant of any kind can be sited in Oregon without the concurrence of the Council and certification by the governor. This is a traditional land-use planning role which must not be surrendered to the federal government.

The Council was influential in regulating the construction of the Trojan nuclear plant in Oregon, and now oversees its operation. The legislature has ordered both the Council and the Director of the Department of Energy to review the security program for nuclear plants and has exempted this review from the public meeting law and the public information law. The Nuclear Regulatory Commission has cooperated by providing a security consultant to advise the Council on such things as the comparative effectiveness of various deterrents.

I hope the essay in the *Review* will not encourage any state to roll over and play dead in the face of federal preemption. State governments have an obligation to participate in the regulation of nuclear power plants — an obligation the states can fulfill far more effectively than can the distant federal government.

W. Kelly Woods
Salem, Ore.

Dr. Woods is Energy Facility Siting Coordinator for Oregon's Department of Energy. — Ed.

Enough is Enough

Harvey Brooks argues in "Distributing Resources for Economic Growth" *(May, pp. 60-63)* that

— redistributing income from rich countries (or people) to poor requires an increase in total product;

— physical resource constraints will not limit growth;

— to satisfy the poor's demand for a bigger slice, we must enlarge the pie;

— economic growth thus "softens . . . conflicts" and is socially and politically desirable.

If the rich spend a somewhat smaller portion of their income on consumption than do the poor, as Dr. Brooks suggests, and if their spending habits do not change, then a bigger slice for the poor does require a bigger pie. But habits and tastes are changing, especially among the young. So our best hope lies in a different sort of growth: the growing awareness that "enough is as good as a feast." Why shouldn't the best educated, best informed, and most privileged people in the world live more efficiently than the world average, rather than so much less so?

Richard B. Parker
Camden, Maine

The Costs of Growth

Jerome Wiesner skims several problems basic to any analysis of the future of technological innovation *("Has the U.S. Lost Its Initiative in Technological Innovation?", July/August, pp. 54-60).* Dr. Wiesner's own description of "replacement technology" seems to confirm a point that some ecologists have been making: that present levels of consumption of energy and resources are not sustainable with present technology. If they were sustainable, there would be no need for replacement technology merely to maintain the status quo.

So as Dr. Wiesner suggests, the failure to develop an acceptable new technology in a given area can have "very damaging effects on the conditions of life. . . ." Dr.

(Continued on p. 68)

The Metaphor Is the Message

Technology/Society
by
Kenneth E. Boulding

The world is so rich and complex that we cannot possibly form a complete and exact image of it in our minds, and still less express this image in language. We are forced to abstract from experience in order to comprehend it at all. And one of the greatest dangers in human images and communications is that we mistake the abstraction for the reality. We mistake the map for the real world and try to go for a walk on it. The general semanticists perform a valuable service by continually emphasizing this truth. It is nearly always the obvious that needs emphasizing, for the more obvious a thing is, the less we notice it.

Abstraction takes two forms: metaphors and models. In a metaphor we imply that something is like something else, that the unfamiliar is like something which is familiar. Familiarity and understanding are not the same thing, of course. We often mistake them, and are beguiled by the illusion of understanding. Metaphor is dangerous because it promotes a sense of familiarity rather than real understanding. We cannot avoid metaphor in communication; both oratory and poetry would be helpless without it. But what is fine for poetry is not always conducive to careful analysis.

Metaphors imply only general similarity. Models imply something more; a one-to-one correspondence between the parts, structures, and relationships of the model and the parts, structures, and relationships of the real world. From a hilltop, with a topographical map before us, we can identify the hills, valleys, settlements, and streams with the names the mapmaker gave them. If there were not exact correspondence with the physical structure we perceive, we would be surprised and probably write an angry letter to the Geological Survey. We can also test the names by going among the natives and asking what they call these peaks and rivers. Here the mapmaker is more likely to be wrong, as he may have had a false informant. My neighbor in the Rockies is an old settler. He can work himself into a lather over the idiocies of the local mapmakers who didn't come and ask him the names of the places they charted.

Maps of Personality and Society

Models of historical, economic, and social systems are fundamentally maps in space and time. They represent the patterns of a four-dimensional reality, as ordinary contour maps represent three-dimensional reality. The larger and more intricate the system, and the smaller the sample we are able to observe, the harder it is to test. Nevertheless, we come to know history, the economy, or society only by making models and testing them.

That is the task of the social sciences. And while we have enjoyed some successes, the task is large and far from complete — if indeed it can ever be complete. Human learning, which lies at the heart of all the dynamics of social systems, is a process of immense complexity, based on a system of 10 billion interacting neurons of which we have only the most fragmentary models. This unabstractable complexity handicaps all attempts to build dynamic models of social systems.

If one reflects that the world social system is an interaction among 4 billion human minds, its complexity may become familiar even if it is not understood. So it is not surprising that we lapse into metaphor even when talking about our immediate social system, of which we have a large sample and wide experience. Think, for instance, of the metaphors we use to describe individuals: tough, pliable, hard, flamboyant, calm, windy, placid, smooth, rough, piercing, cutting, blunt, open, warm, cold, and so on. All these words refer metaphorically to properties of materials or nonhuman objects. The richness of our vocabulary in describing personality is the result of people's multidimensionality. Without models of personality, which despite the efforts of psychologists are still very primitive, we fall back on metaphor.

Words to the Wise

Metaphors are most dangerous in describing large social systems, such as the economic system or the international system. In the depression of the 1930s, before we had any good models of unemployment, we used to talk about "economic blizzards," a singularly unhelpful metaphor. The metaphor of cycles which dominated economic dynamics for a long time is also profoundly misleading, for what we have in social systems are not cycles but fluctuations, which are very different phenomena in that they have strong random movements and not much regular periodicity. The metaphor of the "pie" which is divided into pieces — perpetuated in the ubiquitous pie chart — is also misleading in the study of distributions. There is often no "pie" to divide, but rather innumerable tartlets created in the interactions of production and distribution.

Metaphors have been most catastrophic to the language of international politics. The metaphor of the "balance of power" is extremely misleading. The international system is not a balance, but a perpetual evolutionary disequilibrium. The "domino" metaphor is pretty well discredited by now, but it had a very powerful effect on decisionmakers in the 1960s. The absurd metaphor of the "soft underbelly" may have been responsible for a good many military disasters.

The metaphor may be the message, but it is not a model. If we have a model, metaphors can help us describe it. If we do not have a model, metaphors can be profoundly misleading and dangerous.

Kenneth E. Boulding is Professor of Economics and Director of the Institute of Behavioral Science at the University of Colorado. He writes regularly for Technology Review.

Federal Safeguards on Industrial Chemicals: A Vote for Foresight

Washington Report by Colin Norman

Industrial chemicals have enjoyed the same legal rights as people. We have assumed that they are innocent until proven guilty, and allowed thousands of new compounds to be marketed each year without first requiring proof that they will not damage public health or the environment. And we have paid dearly for our negligence when chemicals such as polychlorinated biphenyls (PCBs) pollute our lakes and rivers, our food, and our own flesh before they are discovered to be toxic.

Consequently, each new chemical that joins the list of hazardous compounds testifies that our assessment of industrial chemicals has been too lax. A new Bill of Rights has been needed, one that requires some proof of innocence before damage is done.

But as usual, it has taken years for that realization to be translated into political action. Since 1971, Congress has considered several bills that would require industrial chemicals to be screened, and some exhaustively tested, before being allowed on the market. Heavy lobbying efforts from industry and from the Nixon and Ford administrations delayed agreement on the legislation for five years. Just before it adjourned for the November elections, however, Congress finally passed the Toxic Substances Control Act of 1976.

Compromised Interests

It is a landmark piece of legislation, probably the most important environmental bill to emerge from Congress since passage of the National Environmental Policy Act and the Clean Air Act in 1970. Though the legislation is weaker than many of its proponents wanted, it breaks new ground by requiring that manufacturers of industrial chemicals notify the federal government before marketing new compounds. The bill also ensures that some types of chemicals are rigorously tested for toxic effects before market approval is given.

The bill had a difficult gestation, and its final version is very much a compromise; hence its passage. Environmentalist groups, among them the Sierra Club, endorsed the measure as a good first step. And the Manufacturing Chemists' Association, the chemical industry's lobbying arm, has also given the measure its unenthusiastic support.

The original impetus for toxic substances legislation came from the Council on Environmental Quality, which reported in 1970 that although some classes of chemicals, such as pesticides, food additives, and drugs, are regulated by law, no federal body has authority even to keep track of the thousands of manufactured chemicals which flood on to the market each year. In 1971, both the House and the Senate passed toxic substances bills. But the Senate version was much tougher than the House legislation; the Nixon administration, in concert with chemical manufacturers, lobbied against both bills; and no agreement was achieved before the 92nd Congress came to an end. Exactly the same pattern was followed in the 93rd Congress, and observers were surprised when the 94th did not repeat the dismal record of its predecessors.

The deadlock was broken at an opportune moment, for the bill emerged from Congress in the middle of the election campaign. President Ford, who had opposed the measure during the congressional fight because he believed it would prove too costly and constitute too much government interference in private industry, was forced to sign it; his veto would have presented Jimmy Carter with a golden campaign issue to exploit.

A Modest Investment

The legislation will work like this: at least 90 days before marketing a new chemical compound, or an existing compound for a new use, a chemical manufacturer must tell the Environmental Protection Agency (E.P.A.) of the name of the compound, its intended use, and any known data on its toxicity. The E.P.A. administrator can then order pre-market testing if he believes the substance may constitute a health hazard, or if it is likely to enter the environment in substantial quantities, or if he finds that there's simply not enough information to judge the compound's toxicity or environmental distribution. He can also order that the compound be kept off the market pending receipt of the required test data.

At that stage, the manufacturer has the right to challenge E.P.A., in which case E.P.A. must seek a court injunction to enforce its order. This provision was the key to agreement on the bill. Essentially, it places the burden of proof upon E.P.A. that regulatory action is justified. The burden would be very light, however, for in order to win an injunction, the Agency would simply have to prove that the compound "may present an unreasonable risk of injury to health or the environment," or that it "may reasonably be anticipated to enter the environment in substantial quantities," or that there is insufficient information for the hazards to be "reasonably determined or predicted." Once E.P.A. obtains its injunction, then the obligation to prove the compound safe will fall on the manufacturer.

At the very least, the bill establishes a coarse filter through which compounds

must pass before reaching the market. Senator Warren Magnuson (D.-Wash.), a key supporter of the legislation, put it a little more colorfully during the Senate debate on the final version. The legislation, he said, "will no longer allow the public or the environment to be used as a testing ground for the safety of these products."

Nevertheless, although the bill is clearly an important development in the regulation of environmental chemicals, it has serious flaws that will limit its effectiveness. Perhaps its chief drawback is the minimal budget it authorizes for establishing and operating the regulatory mechanism. A mere $10 million is set aside for this year, rising to $16 million in fiscal year 1978. Those sums should be compared with the $125 million Congress approved to enforce the Clean Air Act, and the $200 million per year budget of the Food and Drug Administration. Clearly, E.P.A. will be forced to concentrate on relatively few compounds, allowing most new chemicals to slip through the net without being tested.

The bill does require E.P.A. to publish lists of new compounds in the *Federal Register,* following pre-market notification by the manufacturer. That should give people outside the government an opportunity to object if E.P.A. fails to take action on questionable compounds.

The chemical industry worries that toxic substances legislation will impose a potentially large cost burden on manufacturers. A complete battery of animal tests to determine the toxicity of a single compound costs about $500,000, according to officials of DuPont. Consequently, some speculate that the legislation will discourage important new compounds likely to have limited uses. To some extent, however, the concern has been allayed by a provision exempting chemicals produced in small quantities solely for research purposes.

As for the bill's total cost, estimates have ranged from $2,000 million a year — an exaggerated figure suggested last year by Dow Chemicals — to between $80 and $140 million a year predicted by the E.P.A. The cost will be high, in any case. But in relation to the industry's profits, which E.P.A. says amounted to more than $5,000 million in 1974, the investment in protection of public health is relatively modest.

Medical authorities now agree that between 60 and 90 per cent of all human cancer can probably be attributed to environmental factors. A cancer prevention program aimed at diminishing some environmental causes (including cigarette smoking) has long been needed. The Toxic Substances Control Act is a good start.

Colin Norman is Washington correspondent for Nature *and a regular contributor to* Technology Review.

PROFESSIONAL ENGINEERING
FOR
CAPITAL EXPENDITURE PROGRAMS

provides COMPREHENSIVE SERVICES:

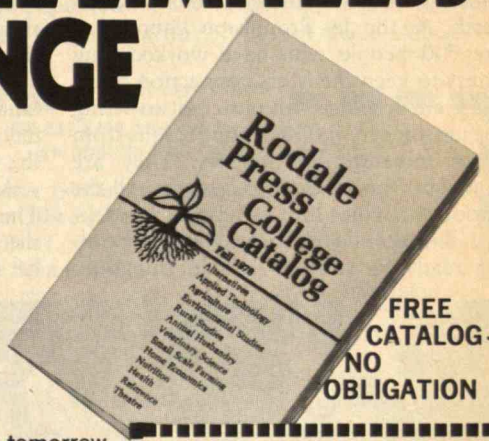
- CONCEPTUAL PLANNING to establish FINANCIAL FEASIBILITY
- PROJECT PLANNING for CAPITAL APPROPRIATION
- IMPLEMENTATION SERVICES for AUTHORIZED PROGRAMS

TO ACHIEVE THE CLIENT'S INVESTMENT OBJECTIVE.

MAIN Engineers

POWER • INDUSTRY • ENVIRONMENT
CHAS. T. MAIN, INC.
BOSTON • CHARLOTTE • DENVER • PORTLAND • TEHRAN
PANAMA • BUENOS AIRES • JAKARTA • LAGOS

FREE CATALOG: OVER 50 BOOKS THAT FACE THE LIMITLESS CHALLENGE OF A LIMITED WORLD.



FREE CATALOG— NO OBLIGATION

Students will face the challenge tomorrow.
Scientists and technologists face it right now.
Indeed, virtually everyone does.
That's why almost every book published by Rodale Press is aimed at showing people how to live and work in a world whose resources have become gravely restricted and too expensive.
Rodale's books—ideal for supplementary use in a wide variety of disciplines—range from Alternatives and Applied Technology to Ecology and Environmental Studies; from Veterinary Science to Nutrition; from Agriculture to Home Economics.
If you specify textbooks or supplementary reading materials, we invite you to send for a complimentary copy of our College Catalog.

BDC 2

Rodale Press
Educational Department
33 East Minor Street,
Emmaus, PA 18049

Please send me, without charge, a copy of Rodale's current College Catalog.

Name_____
Title/Dept._____
School_____
Address_____
City_____
State_____ Zip_____

Space Cowboys on the Martian Frontier

National Report
by
David F. Salisbury

A thin tendril of radio waves has been stretched from earth to Mars. Our perception of the red planet will never again be the same.

The hardware which made this possible is Viking: two spacecraft in orbit around the 200-million-mile-distant planet and two sitting on the rock-strewn surface.

These are complex machines. They took a small town of scientists, engineers, and technicians almost a decade to design and build. Each Viking lander, for instance, weighs only 605 kilograms but is made up of 1,450,000 parts, each painstakingly designed, built, and tested.

Yet Viking is much more than sophisticated hardware. As complicated as it is, the hardware is only the tip of the iceberg. Behind each Mars picture and datum returned is a unique group of people.

Putting the Moves on Mars

Most of the Viking mission takes place on earth. At the Jet Propulsion Laboratory are 700 people who have worked long hours to keep the Mars connection open. They are scientists who attempt to wring the most meaningful scientific results from often reluctant instruments. They are planners who attempt to integrate all the various activities into a compatible package, day after day. They are troubleshooters ready to jump in should things go wrong. They are computer programmers who run the ten large ground computers necessary to process instructions to the spacecraft and sort the returning data.

Exploring the planets is heady stuff to these people. It is risk-taking on a magnificent scale. It is a war of intellect and planning against the unknown.

Viking has a billion-dollar stake in the four spacecraft. The rewards of success are hundreds of times more information about this alien planet than have been garnered from centuries of stargazing.

It is unfortunate that much of the effort's human drama is not better communicated. There has been enough anecdote, suspense, and conflict in the Viking mission to more than fill a good movie.

For instance, there is Director of Mission Planning Gentry Lee's recurring premonition. His wife was due to have their first child about the time of the first Viking landing. He was obsessed with the thought that both events would come on the same day. Although both the landing and the birth were repeatedly delayed, the lander had been on the surface 12 martian days before Mrs. Lee gave birth to an 8 lb., 8 oz. baby.

And there is Brown University geologist Tim Mutch, who became so engrossed in the tests of the lander camera system that he somehow confused it with the real thing. He rode home full of exaltation at the success and only realized his mistake when his wife reminded him that it was simply a test.

Hectic activity preceded the first landing. As the orbiting spacecraft sent back pictures of the prime landing site in Chryse, the Viking manager, James S. Martin, Jr., was appalled to see rugged terrain when he had expected an easy, safe landing site.

The orbiter began searching other areas. But everywhere the martian surface looked rugged. Matters became so tense that Mr. Martin exploded when he walked into the landing site selection group's office. Triggering the outbreak was the fact that one of the landing ellipse overlays which Mr. Martin liked to push around on the photomosaics of the landing area was taped down.

A delirious sense of release swept through the Space Flight Operations Facility and other Viking offices when the telemetry and first pictures revealed the gamble won and the spacecraft safely down. With champagne in styrofoam cups, the Viking team members celebrated the fruition of seven or more years' effort and commitment.

And then the biology team nearly went into shock when the first results from the life detection experiments showed violent chemical reactions instead of the lack of activity or instrument failure they expected and feared.

These are only a few examples that illustrate why many of the Viking people are hooked on space exploration.

To the dedicated workers in the planetary program, Viking holds a special poignancy. Many of them have no idea what they will be doing after this mission is completed. Only two more space missions have been funded — probes to Venus and Jupiter and Saturn — but they will not keep all the team busy.

Who can blame the mission scientists and technicians if they find other lines of work mundane after wresting secrets from the distant planets?

Members of the Viking team are the first to see close-up pictures of the Mars surface, transmitted from the Viking I lander to mission headquarters at the Jet Propulsion Laboratory, Pasadena, Calif., on July 22. (Photo: Wide World Photos, Inc.)

David F. Salisbury is Science Editor of the Christian Science Monitor *and a regular contributor to* Technology Review.

Amazing Encyclopedia Bargain Explained—Why The Recession Forced The Webster Company To Slash $350 Price To Only $175

20 Deluxe Volumes—65 lbs.
11,905 Pages—9,500,000 Words—30,060 Articles.
14-Day Free Home Trial
Phone Toll Free, Anytime

Noah Webster (1758-1843). Father of lexicography and inspiration for founding of our company.

We mean it. We're in deadly earnest when we say that here is the most incredible encyclopedia bargain on the market today. The reason for the low price? Simple. **The Webster Dictionary Company's top-rated Encyclopedia Division is caught in the economic recession bind.** And just as the automakers offered rebates to drastically improve their sales, so does Webster announce an incredible price slash to turn inventory into immediate cash and avoid the high cost of borrowing.

Think of it. THE NEW AGE ENCYCLOPEDIA is top-rated by the most authoritative guide in encyclopedias, GENERAL ENCYCLOPEDIAS IN PRINT. They rate it among the top encyclopedias in the world, **regardless of price. A bargain at the bookstore price of $350. Now you can get it for an incredibly low $175—only 50% of the bookstore selling price—during this emergency money-raising sale.**

All this plus a previously unheard of money-back guarantee. It is sent to you on a free 14-day home trial basis (no salesman will call). Thumb through it as often as you wish. You must agree with the experts who rate it high among the top encyclopedias in the world—**or simply repack in original crate and ship back to us. Your money—plus the original shipping charge—will be refunded promptly and without question.**

The New Age Encyclopedia is a joy to peruse. Over 11,905 pages, 9,500,000 words, 30,060 articles, 13,489 illustrations, 3,500 in color. More than 1,050 Location, Relief, and Political Maps. A massive compendium of man's knowledge, updated to 1976. An exciting glimpse into the breadth of man's accomplishments. A huge 20-volume set that keeps you as well informed on any subject as the scholars who compiled it. Self-indexing, with references to related information in all 20 volumes. So fascinating that once you become immersed it is hard to stop reading. **No finer way ever devised to help you become the well-read, totally informed, well-rounded, and complete person everyone wants to be.**

And, most important of all, as an added bonus, you get a FREE 10-YEAR READER RESEARCH SERVICE on any question. **This allows you to ask our staff of over 4,000 contributors, all experts in their field, an unlimited number of questions for ten full years on any subject, with the exception of legal or medical advice, at no charge whatsoever.** This is just like having your own research department available to you on a moment's notice. And the service is FAST. Normally 10 days from the time the request is received by the publisher you have your answer in full detail.

You can't lose. Clip out this message as a reminder. This is an emergency money-raising special. **The one-half the bookstore selling price is for a limited time only, and may never be repeated.** Write or call now. Our toll free lines are open 24 hours a day, 7 days a week. Allow 3-8 weeks delivery.

Credit Card Buyers
Phone Toll Free
800-241-8444 And Ask for Operator 519
Or Mail No-Risk Coupon Today

The Webster Dictionary Company, Inc.
Executive Offices, Dept.
Dept. TRE-N1, Suite 500, 625 North Michigan Avenue
Chicago, Illinois 60611

Please send me _____ set(s) of the renowned, authoritative, 20-Volume, 11,905-Page, 9,500,000-Word, 30,060-Article, $350 list price **New Age Encyclopedia** at the unprecedented low price of only $175 each! (plus $10 per set for crating and freight). I understand that if I'm not satisfied I may return within 14 days for a prompt and courteous refund. On that basis here is my order.

(Check One)

☐ I enclose payment
☐ Bill to:

Bank Americard No. _____
American Express No. _____
Master Charge No. _____ Inter Bank No. _____
Expiry Date _____
Name _____
Address _____
City _____
State _____ Zip _____

Ironclad Money Back Guarantee

©Copyright 1976 The Webster Dictionary Co., Inc.

Genetic Engineering: The People's Choice

Special Report
by
Sara Jane Neustadtl

Cambridge, Mass., has made the question whether to pursue research on recombinant DNA city business. Confused by conflicting testimony of expert scientists and distrustful of guidelines the National Institutes of Health has written to safeguard the research, the city has appointed a committee to review the issues and recommend an appropriate response.

At issue is the right of scientists in Cambridge to take advantage of a dramatic new method in biology. Scientists have developed a technique to join genetic material from two organisms of distinct species, and insert these hybrid elements in bacterial and animal cells. Some claim this to be the biggest breakthrough in biology since the invention of the microscope. Others say organisms thus produced might be totally new, never seen on earth before, and might be so dangerous that they should not be studied in an urban setting.

The matter was first presented to the citizens of Cambridge when Mayor Alfred E. Velluci discovered Harvard University's plans to establish a new laboratory for genetic research. A similar laboratory is being completed in M.I.T.'s Center for Cancer Research, where scientists propose to conduct experiments on recombinant DNA. Mayor Velluci perceived that no mere building permit was in question, but a matter the scientific community has debated since the techniques first became possible (*see October/November, pp. 10-12*). He called for explanations.

Unquestionable Dangers

Both supporters and opponents of the research spoke before the Cambridge City Council early this summer. Among those urging that the research be allowed to continue was Nobel laureate David Baltimore.

The research, said Dr. Baltimore, is in the best interests of the citizens of Cambridge. The synthesis of new and inexpensive drugs, deeper knowledge of the body's immune systems, new therapies for the treatment of cancer, and greater control of health are at stake.

There are possible, though unproven, risks, Dr. Baltimore continued. So it is the responsibility of the scientific community to conduct its experiments under the safest conditions possible. He went on to explain safety procedures recommended by the National Institutes of Health.

Some experiments with recombinant DNA are unquestionably dangerous, and the N.I.H. guidelines outlaw them. Experiments with genetic material from organisms known to produce toxins, the transfer of resistance to antibiotic drugs from organism to organism, and the deliberate release of DNA recombinants into the environment are all prohibited.

The potential danger of experiments allowed by the N.I.H. varies, depending on how similar the donor organism is to man. The higher the donor of DNA on the evolutionary ladder, the more stringent the requirements. Any experiment using human cells, such as those M.I.T. Professor Phillip Sharp proposes to use to study immune behavior in humans, must take place in a "moderate" containment facility.

Two such facilities, dubbed "P-3" in the guidelines, are now planned in Cambridge, and triggered the present controversy.

Conversion of a lab to P-3 standards costs about $50,000, and represents a commitment to recombinant DNA research by the institution that undertakes it.

Special air vents separate the P-3 lab from surrounding rooms, and the outgoing air is treated before it is released. The room maintains negative air pressure, which guarantees that microorganisms will enter but not escape when the door is opened. None of the equipment, instruments, or clothing can be reused in another lab; experiments take place in special cabinets that have their own negative air pressure devices, and ultraviolet light shields the lab from the cabinet. In addition, procedural rules must be followed: for instance, front-buttoning coats are not allowed, and workers in the lab must take care of its upkeep.

Biological as well as physical containment is required: microorganisms are enfeebled so that they cannot survive outside the lab long enough to reproduce or pass on genetic materials.

In addition, the N.I.H. expects experimenters to adhere to "good microbiological practices." Lab workers are taught antiseptic techniques, the biology of the organisms they handle, and emergency procedures.

Jonathan King, Associate Professor of Biology at M.I.T., finds these measures insufficient. A potential benefit to be realized 20 to 50 years in the future does not warrant the more immediate threat to our lives and health, he told the City Council. Organisms reproduce; once escaped, they cannot be stuffed back inside the test tube. The N.I.H. guidelines were written by scientists having vested interest in the experimentation, rather than by people who must live and work in communities where the experiments are conducted, said Dr. King. Thus he and other scientists doubt the efficacy of the containments proposed by the guidelines. While organisms are enfeebled, they are not killed, he explained. And despite elaborate technical safeguards, people must still go in and out of the labs.

Strains of *Escherichia coli* are the bacteria of choice in recombinant DNA research; *E. coli* is also the principal inhabi-

tant of the human gut. So even if the bacteria were crippled, they might still find comfortable homes in the bodies of the experimenters, and ultimately contaminate people on the outside.

Our only choice is to proceed slowly, said Dr. King, and in the meantime to call a moratorium on the research in Cambridge. The decisions we face must not be left to scientists.

A Lack of Trust

Following hours of conflicting testimony, the City Council agreed that a moratorium was indeed justified, at least until the City Mothers and Fathers had had an opportunity to study the issue. A three-month "good faith" moratorium was announced, and an Experimentation Review Board was appointed. The Board will advise the Cambridge Commissioner of Health and Hospitals. It is not clear whether the City Council has legal authority to stop the research. But the Commissioner does have power to order the institutions to cease and desist, if he deems the research is hazardous to the citizens' health and safety.

The Board is a group of eight citizens charged to review the N.I.H. guidelines and advise the Commissioner, who sits on the panel ex-officio. Among its members are a Tufts University lecturer in public policy, a former public health nurse, a clerk who has been active in other community decisions, and an engineer.

The Board's general lack of scientific expertise is no accident. The City Manager, James L. Sullivan, says he used jury selection tactics in making his appointments to avoid a biased panel that would probably fail to reach a consensus.

The Board has been meeting regularly since August. When the moratorium ended in October, the Board was granted an additional three months to make its recommendations. The Board is trying to assess the risks as they apply directly to Cambridge. It is evaluating the N.I.H. guidelines, inspecting the experimental labs at Harvard and M.I.T., and examining the conditions under which they operate.

The Cambridge City Council is nervous about federal interference. Barbara Ackermann, City Councillor and former Mayor of Cambridge, says that while judging the guidelines' relative merits is the business of the state and federal governments, "We don't trust them."

"People say the federal government is bigger and better equipped, and a small city government should defer to its recommendations. Maybe 15 years ago I would have said so, too, but now we're so skeptical," she told a recent meeting of the Board.

The skepticism which moved so many scientists to go over the heads of the N.I.H. and bring the issue to the people makes her wonder whether the N.I.H. guidelines were established fairly. "The fact is, I don't think the City Council could have ignored this question, considering the stature of the people who are raising it," said Ms. Ackermann.

To one board member, the guidelines are merely a jumping-off place. They set only minimum standards of safety. Sheldon Krimsky, Associate Director of Tufts University's graduate program in urban, social, and environmental policy, has "never been persuaded that one should seek minimum standards simply to achieve universal applicability." Part of the Board's job, he says, is to determine for itself what safeguards are necessary to protect the special and specific needs of Cambridge.

On the other hand, so eminent a scientist as Dr. Baltimore has been telling the Board that the standards are far from minimal. They provide "abundant, extra measures of safety" which almost guarantee that the research does not pose hazards of its own. Further regulation would only "hamstring" the research, he says.

An Acceptable Risk?

Issuance of special "Cambridge guidelines remains a very real possibility, if the questions of Board members are any indication. An implicit worry is the relationship of ideal standards to the quotidien realities of university-based research. And here a rare area of agreement is uncovered: board members and scientific personnel alike consider the least easily contained danger to be human error.

"Does this sort of research belong in a university?" asks Councillor Ackermann. She thinks, "Maybe a student-manned lab is unappropriate to the research."

Salvador Luria, Director of M.I.T.'s Center for Cancer Research, defends M.I.T.'s precautions to the Board. The research takes place in a serious environment, he says. The probability that a pathogenic organism will be created and escape elaborate physical containments as the result of an inadvertant error is "vanishingly small," he told the Board.

Perhaps in anticipation of additional local guidelines, M.I.T. considers the N.I.H. recommendations as minimum standards, Dr. Luria said. For example, a double exhaust fan with an automatic control has been placed in M.I.T.'s P-3 lab. Thus no organism can escape because of a power failure.

Still, installations such as this are only as safe as the care taken by the experimenters who use them each day. "Why aren't all recombinant DNA experiments done in P-3 labs?" asked one Board member.

"Researchers know that some experiments aren't sufficiently hazardous to warrant such care. They wouldn't take kindly to unnecessary barriers to their research," Dr. Luria replied.

Assessing the attitudes of researchers can be tricky. On the one hand, as Dr. King emphasizes, "The last person I'd want to protect me from a danger is someone who doesn't think there is a danger." On the other hand, Ms. Ackermann points out that the methodology is available to all. No one could use it more safely and productively than the experts at M.I.T. and Harvard.

In accordance with N.I.H. guidelines, both Harvard and M.I.T. have appointed biohazards committees composed of public and environmental health experts and laboratory workers as well as biomedical and genetics researchers. These committees have now written some guidelines of their own, supplementing those of N.I.H.

The committees guarantee that each lab worker makes an informed choice whether to be exposed to potentially hazardous microorganisms. All employees are briefed on the cells they are handling and the safeguards they require. Blood sampling programs sponsored by the committees monitor workers over the months they are involved in recombinant experiments. And infractions of any regulation can be reported anonymously to the committee chairperson.

The possibility remains that the voluntary regulation of M.I.T. and Harvard will be considered insufficient by the Board. As of this writing, Board members don't believe they can be too cautious. They continue to ask, "Can we allow even the smallest risk to exist? What if the impossible happened?"

Even if the research is banned in Cambridge, it will go on elsewhere. Both Harvard Medical School and Boston University — just across the Charles from Cambridge — could conduct recombinant research. A dangerous pathogen would not honor city boundaries. Banning the research in Cambridge might serve only to drive some of M.I.T. and Harvard's most active and productive scientists to cities where their research is more welcome.

"We don't want to make that consid-

Continued on p. 72

Trend of Affairs

Trends This Month

BIOLOGY

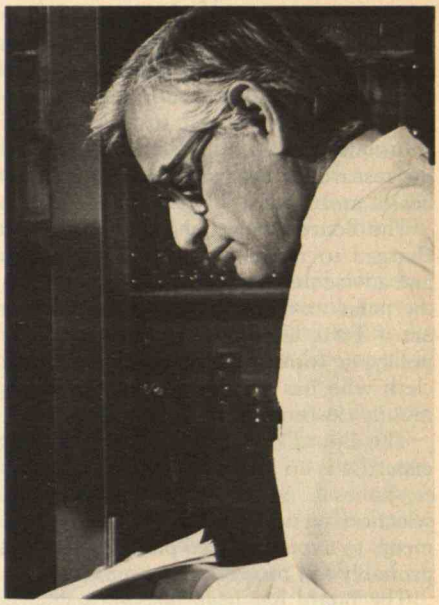
The Artificial Gene

After nine years of painstaking, complex laboratory work, Nobel Prize-winning biochemist Har Gobind Khorana and 24 colleagues have built a gene that functions in a living cell. Their announcement last September at the annual meeting of the American Chemical Society was universally applauded.

From common, off-the-shelf chemicals, the M.I.T. scientists synthesized a gene found in the bacterium common to the human gut, *Escherichia coli.* They incorporated the gene into a virus for testing, and the virus utilized the gene as part of its own machinery of heredity. (The gene coded for a particular type of "transfer RNA," a molecule which operates in the protein synthesis machinery of living cells to transfer an amino acid to sites where they are incorporated into proteins.)

The fact that the string of 207 units, called nucleotides, functions in a living cell confirms the basic biological theory that the DNA gene is the basis — the only basis — for heredity. Not that the theory was in doubt, but it is encouraging to find that no constituent of chromosomes necessary to gene functioning has been overlooked.

The gene synthesis also opens the way for highly precise studies of gene function. Molecular biologists can now synthesize artificial genes or gene segments with nucleotide sequences differing in known, precise ways from the natural gene. Especially mysterious is the puzzle of how the control mechanisms within genetic material funtion. Only a small part of a living cell's genetic material is devoted to instructions on *what* cell component to make. The majority of genetic material consists of control signals governing *when* to make it. The gene synthesized at M.I.T. includes the "start" and "stop" control signals that govern the living cell's "reading" of the nucleotide sequence of the gene. Studies of how these signals function with various changes in the sequence of nucleotides should aid understanding of gene control.



Dr. Har Gobind Khorana, Sloan Professor of Biology and Chemistry at M.I.T., led the research team that synthesized the first working gene. (Photo: Calvin Campbell)

Dr. Khorana's work on deciphering the genetic code, by which gene DNA sequences are translated into working cell proteins, earned him a share in the 1968 Nobel Prize in Medicine or Physiology. The synthesis by him and his colleagues of the artificial gene may help open the way to understanding how the control DNA sequences are translated into on-off instructions for the cell's genes.

The problems in synthesizing the gene would thrill puzzle freaks everywhere. The scientists had to join the 207 units successfully, and in the right order. They also had to prevent the myriad side reactions made possible by the complex nucleotide strings from interfering with the synthesis. They had to develop many new techniques. New methods for rapidly separating and analyzing the molecular products reduced process times in many cases from weeks to hours. New "blocking" agents were also developed that pro-

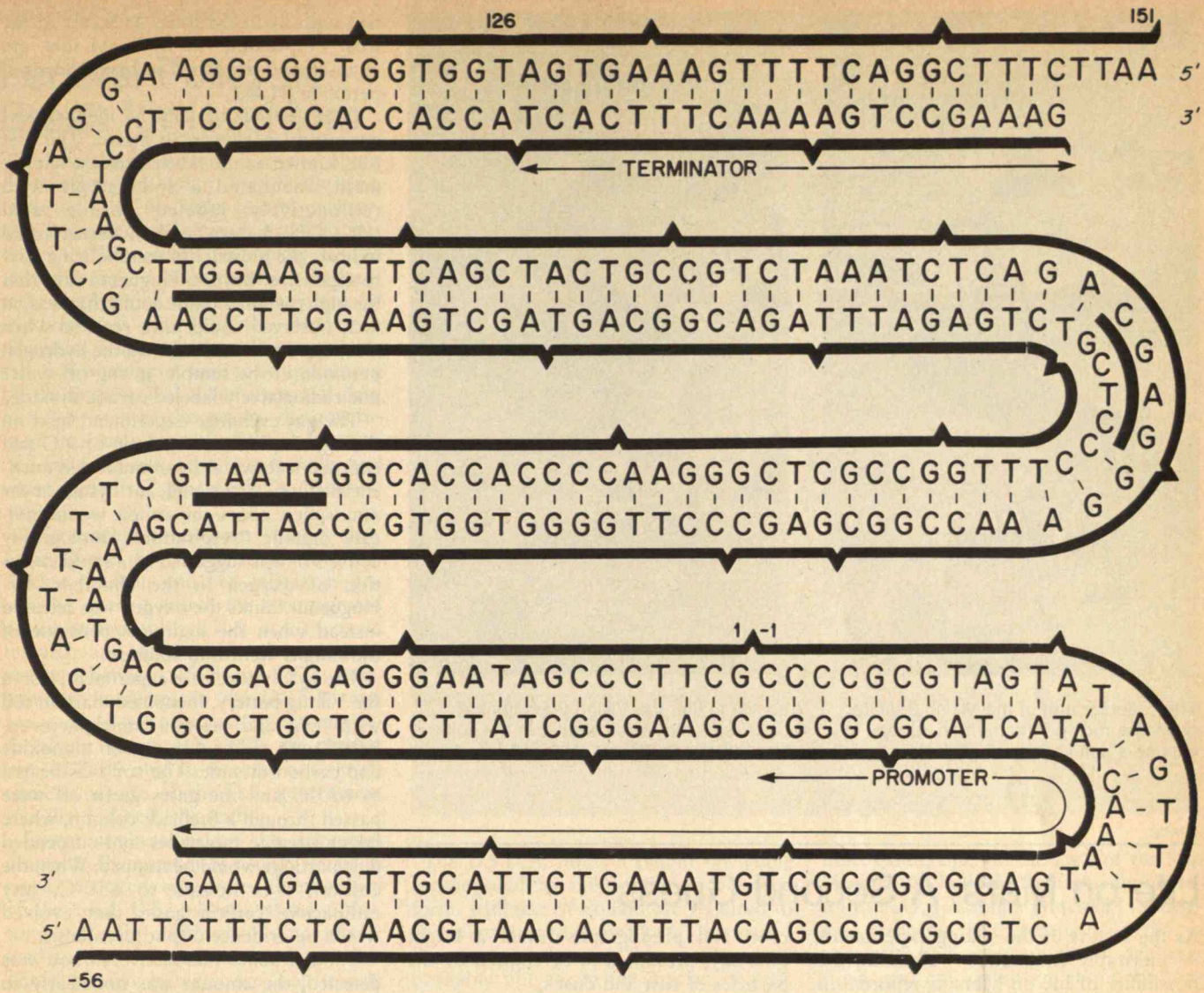


Diagram of complete double-stranded structure of synthetic *E. coli* tyrosine transfer RNA gene, including control elements (promoter and terminator), synthesized in the laboratory of Dr. Har Gobind Khorana at the Massachusetts Institute of Technology. Segments between points were synthesized chemically, then joined enzymatically to form the entire DNA double helix.

tect those parts of the molecules that would undergo side reactions during the synthetic operations. Such agents are large molecules that can be easily attached to a part of a molecule to be protected before a synthetic operation, and detached afterward.

The scientists used chemical techniques to construct strings of nucleotides 10 to 15 units long, and then joined these longer segments with enzymes known as ligases.

The spiral-staircase-shaped DNA molecule consists of a double-stranded chain of nucleotides (the "side-rails" of the staircase), with each nucleotide linked to the corresponding nucleotide on the other chain by hydrogen bonds (the "steps" of the staircase).

Four basic nucleotide building-blocks make up the string of DNA — adenine, thymidine, guanine, and cytosine. All double-stranded DNA molecules have "complementarity," so that each adenine on one strand is linked to a thymidine at the same spot on the other strand, and each guanine on one strand is matched by a cytosine on the other. Each complementary nucleotide naturally bonds to its opposite-strand partner because of the pairs' mutually attractive chemical forms, like two complementary parts of a puzzle.

In their synthesis, Dr. Khorana and his colleagues took advantage of this complementarity. Each short, chemically-synthesized double-stranded segment possessed a few extra single-stranded units extending from it. When new segments were added, the single-stranded complementary segments attracted one another, and acted as a "splint" to hold the strand together while the enzyme sewed the two segments together.

The announcement of the gene synthesis was greeted by minor confusion on the part of the press, which lumped Dr. Khorana's achievement with experiments with recombinant DNA. In these experiments, whose safety is now under debate, segments of DNA from one organism are joined with the genetic material of another, producing hybrid organisms. However, Dr. Khorana's work consisted of building a natural gene from a common organism and represents no danger whatsoever.

Although Dr. Khorana and his colleagues stress that their gene is minuscule compared to the average human gene which can consist of thousands of nucleotides, scientists still feel that he has broached a psychological research barrier: the gene seems less an overwhelming entity than it once was. Dr. Khorana's research, and the other powerful techniques for gene manipulation (*see* Technology Review, *October/November, pp. 10-12*) have brought treatment of hereditary diseases via artificial gene insertion, and understanding of the basic secrets of gene action, closer to the realm of human possibility. — *D.M.*

The collector arm of the Viking 2 lander pushes a rock on the martian surface to expose a soil sample. If ultraviolet light is hostile to life, the Viking team thinks organisms may seek shelter in the soil beneath rocks. (Photo: N.A.S.A.)

SPACE

Life on Mars: A Second Guess

As the results of the Viking experiments — inevitably enigmatic — come in, the possibility of life on Mars as reported in the daily newspapers oscillates between a triumphant "maybe" (on page one) and a desolate "maybe not" (on page 12). No one, least of all the Viking team, knows for sure whether the activity observed in experiments on the landers is chemical or biological. That puzzlement is interpreted by readers as waffling on a cosmic scale.

A theory to explain the process of martian weathering may tip the balance toward a purely chemical explanation, appeasing our frustration, if not our hopes for extraterrestrial companionship.

Robert Huguenin, a staff researcher in the Department of Earth and Planetary Sciences at M.I.T., explained the theory to scientists assembled at the Jet Propulsion Laboratory last August.

According to his model, iron-bearing minerals in the martian surface alter to rust (ferric oxide) and other substances when exposed to atmospheric oxygen, carbon dioxide, frost, and ultraviolet sunlight. As a result, rust scales — 100 times smaller than grains of beach sand — on rock and mineral surfaces are easily dislodged by windblown dust and sand, and float in the thin martian atmosphere. Viking experiments confirm sufficient oxygen for the process to occur (about 0.3 per cent) and photographs reveal a bright pink sky, presumed to be colored by the particles of rust and dust.

This weathering takes place photochemically, without the liquid water or rain requisite on earth. So in effect, the red planet is "sunburned and peeling as a result of exposure to ultraviolet light," says Dr. Huguenin.

The model, first advanced in 1974 and based on laboratory studies Dr. Huguenin conducted at M.I.T. in 1972, was designed to explain why Mars is red. But it has implications for the results of the three life-seeking experiments on board the Viking landers.

The soil samples tested in the experiments were gathered on the edges of bright areas in western Chryse Plain and, further north, in Utopia Plain. According to the model, brightness implies dusty, weathered terrain and dark areas suggest unweathered regions. Assuming the soil samples contained at least a tenth of a per cent of unweathered soil — reasonable, thinks Dr. Huguenin, given the landers' positions — the following chemical tableau explains the Viking results:

Water vapor, condensing on the unweathered surface, is "ripped apart" into hydroxyl ions (OH) and hydrogen ions (H). The hydrogen ions are incorporated into crystals, leaving a layer of frost studded with hydroxyl ions. As water in the frost evaporates, the hydroxyl ions are exposed and combined to form hydrogen peroxide (H_2O_2).

Enter the Viking landers, identical experimental packages on board. The first test, known as the labeled-release experiment, incubated a soil sample with radioactively labeled formic acid (HCOOH). Labeled carbon wastes would indicate the presence of metabolizing microorganisms. But Dr. Huguenin says that the high carbon dioxide count that was, in fact, observed could have resulted when the formic acid reacted with the hydrogen peroxide in the sample, giving off water and radioactively labeled carbon dioxide.

The gas exchange experiment, next on the agenda, heated a sample to 9°C and exposed it to water in an unlabeled nutrient medium. Any significant change in the atmosphere above the sample would indicate organic "respiration." Biologically active soil was suggested by a rapid evolution of oxygen in the chamber. Dr. Huguenin thinks the oxygen was released instead when the hydrogen peroxide of the sample went into solution.

The pyrolytic release experiment, last in the Viking battery, incubated martian soil with light and martian atmosphere enriched with radioactive carbon monoxide and carbon dioxide. The soil was heated to 625°C and the gases given off were passed through a firebrick column, where larger organic molecules and suspended dust particles would be trapped. When the column was heated to 650°C, any radioactive carbon gases that evolved would be evidence of photosynthesis.

Though some radioactive carbon was detected, the amount was not nearly so great as in the previous experiment. Predictable, says Dr. Huguenin, since radioactive carbonate complexes would have formed in the soil when the sample was incubated, and survived when the soil was heated. Some soil carrying radioactive carbonate may have been trapped in the column, accounting for the low radioactive carbon count finally observed. Evidence, thinks Dr. Huguenin, of chemical rather than biological activity.

Is the planet a biological wasteland? "There may be life on Mars, after all," Dr. Huguenin maintains. "I'd love to think so. But the experiments on the landers don't prove it." He hopes later expeditions will focus on bright, weathered regions that should be exempt from the compromising chemicals of unweathered soil.

The proof of the theory remains to be established. But if it is correct, some future mission — not yet authorized by Congress — may yield the evidence of life that so far has eluded Viking.

Maybe not. . . . — *D.McG.*

Federal Policy: A Break for Inventors

The federal government, in casting about for a technology policy, may finally have come up with the right central concept, says Betsy Ancker-Johnson, Assistant Secretary for Science and Technology for the Department of Commerce. "Federal technology policy ought to concentrate on innovation," she told the American Chemical Society in San Francisco this fall. A new program soon to be announced by the Secretary of Commerce will contain "the sum of the actions the government can employ to induce innovation and put it to use, both domestically and internationally," promised Dr. Ancker-Johnson.

Encouraging innovation should slow some of the disquieting trends that Dr. Ancker-Johnson and her colleagues discovered in their search for an integrated policy on technology. U.S. investment in research and development decreased 12 per cent between 1969 and 1973, compared to increases in the U.S.S.R. and Japan of 43 per cent and 70 per cent respectively. During the 1960s, the percent of G.N.P. devoted to research and development outside of the U.S. government actually declined, she said.

Patent applications by U.S. inventors dropped. The number of patents issued to non-U.S. citizens constitutes about a third of the total U.S. patents issued today, compared with a fifth of total patents issued to non-U.S. citizens ten years ago. These foreign patents are not merely gimmick items but important developments in advanced technology, said Dr. Ancker-Johnson.

"Technological innovation is the aggregate of whatever is necessary to produce new goods and services, or to produce the ones we already enjoy better or more cheaply," she said. Thus a decline in innovation must result in a decline in productivity. Unemployment, trade deficits, inflation, dollar devaluation, and a lower standard of living all see their beginnings in lowered productivity, she said.

The federal government can best counter these trends by making low-interest or interest-free loans to industrial research, by supplying grants to industry as well as universities for generic research, such as studies into better methods of preventing corrosion. The Department of the Treasury could use tax measures to give "breaks" for innovation. Consumers, local and state governments, and industry could utilize today's excellent federal information dissemination systems to communicate ideas and needs to one another.

To aid innovation the federal government should also get out of areas where it does not excel, such as the commercialization of government-developed inventions. "The U.S.D.A. holds a patent on whole (as opposed to skim) milk in powered form. Millions of dollars are required to commercialize this product," explained Dr. Ancker-Johnson. "The product will probably not go on the market because the government cannot guarantee exclusive licensing of the method to the company that would make the investment."

A new federal policy that leaves invention in the hands of the inventor rather than in the hands of the government is the answer, she said. "Over 26,000 patents are owned by the U.S. government, and only 1,000 are in use because there is no protection for the investor."— *S.J.N.*

A Lawyer's Look at a Kelp Farm

You are the head of the Naval Undersea Center in San Diego. E.R.D.A. and the American Gas Association have funded your Center to deploy an Ocean Kelp Farm — a 100,000-acre system of subsurface rafts in the Atlantic or Pacific — on which to cultivate giant kelp. The harvest will be enough to meet from two to five total annual man requirements of methane, methanol (feed stock for chemical and fertilizer manufacture), and animal feed per acre.

What will your lawyer say about your rights to thus claim space and nutrients in the sea?

If your lawyer is Lawrence G. Mallon (he's associated with Ball, Hunt, Hart, Brown, and Baerwitz, Los Angeles attorneys, and was formerly with the University of Southern California Sea Grant Program), he will ask you to work hard on predicting all possible adverse consequences and avoid as many of them as you can. He'll warn you that you are entering legal waters still uncharted because the Law of the Sea (*see below*) remains unwritten.

The farm will interfere with freedom of navigation on the high seas; you will have to negotiate an avoidance zone with the Intergovernmental Maritime Consultative Organization. There will be complications if you want to move the farm from place to place in the sea to obtain new resources of nutrients. There is legal precedent for complaints from countries down-current of the project if it causes a nutrient deficiency which is reflected, for example, in poor fishing. That will be a special hazard if — as planned — you "fertilize" the kelp farm with an artificial upwelling of nutrient-rich bottom waters. Those cold bottom waters may cause fog over the site, suppress wave action, and affect ocean reflectivity; N.O.A.A. and the Coast Guard will thus be interested.

Mr. Mallon — he spoke at the Marine Technology Society's "Ocean '76" meeting in Washington last fall — admits your claim to the use of ocean space is a "novel" one. But he thinks it can be "justified under present international law as an extension of sovereignty and property rights," and he will suggest you proceed. — *J.M.*

Gloomy Prospects for a Law of the Sea

Prizes from the sea were unguarded and alluring in the early 1700s. Agreements among pirates of the Caribbean lasted no longer than the time it took to sail out of sight. Dividing the wealth of the modern seas presents the same difficulties, but the scale of the competition has grown.

Pessimism on prospects for international cooperation on marine resources engaged most participants in the 1976 annual meeting of the Marine Technology Society ("Oceans '76") this fall. The M.T.S. meeting took place just before the end of the fifth session of the Third United Nations Conference on the Law of the Sea. Howard W. Pollock, Deputy Administrator of N.O.A.A. and a principal U.S. delegate, reported to "Oceans '76" that a paralysis had infected those deliberations, and any optimism about the proceeding had vanished.

The stalemate arose over the thorny issues which perpetually separate developed and developing countries — "ownership" of the resources of the deep seabed. At the previous Law of the Sea Conference, an international authority seemed the means to share resources between industrial and developing nations. But this time the particulars of managing and financing the proposed International Seabed Resource Authority separated the two sides, said Dr. Pollock. The 110 developing nations exerted what he called a "tyranny of the majority" over the 157-nation Conference.

Dr. Pollock saw no foreseeable resolution on the rights of all nations — large and small, landlocked and coastal — to the high seas. The Arab states, who wish to preserve their monopoly on inexpensive oil, oppose any arrangements for exploitation of seabed resources beyond the 200-mile limit. Other nations, depending on their geography and natural resources, argued vehemently about whether their royalties on undersea exploitation should be 5 or 7 per cent.

The developing countries also united to insist on the right to control scientific re-

search of all kinds in their territorial waters; the U.S. and most developed nations proposed limiting this right of control to resource-related research.

Among the other questions was whether migratory fish were to be under the jurisdiction of the nation in whose waters they happen to be swimming or under an international agency. There were also problems of pollution controls for all commercial shipping, the U.S. standing alone in its insistence on strong rules. The conferees argued over whether new marine technology should be the property solely of its inventor or whether it should be shared to benefit developing nations which especially need it. Finally, there was the question of how disputes arising under a final Law of the Sea should be resolved.

Perhaps the only bright note in the proceedings was that collaboration in marine science and exploration continues unabated with each country excelling in its own specialties. Canada, whose continental shelf is one-third the size of its land mass, is concentrating research on sea ice and tidal forces. The German shipbuilding industry builds almost as many oceanographic vessels as conventional commercial ships. The French are studying aquaculture and offshore sand and gravel resources. The Japanese, seeking power and minerals from the sea, are working on deep submersibles and basic research on wind and waves. For centuries the Dutch, specializing in land reclamation, have been Europe's best builders of ports, levees, and dams. A. N. Kosarev of the Geography Department at Moscow State University spoke openly of work in the U.S.S.R. linking oceanography, meteorology, and climatology.

Dr. Pollock termed the Law of the Sea Conference's rescue a monumental task. However, he said, the alternative to movement is collapse. It is a curious case in which the more technology man has developed, the less his chances of agreeing how to use it. — *J.M.*

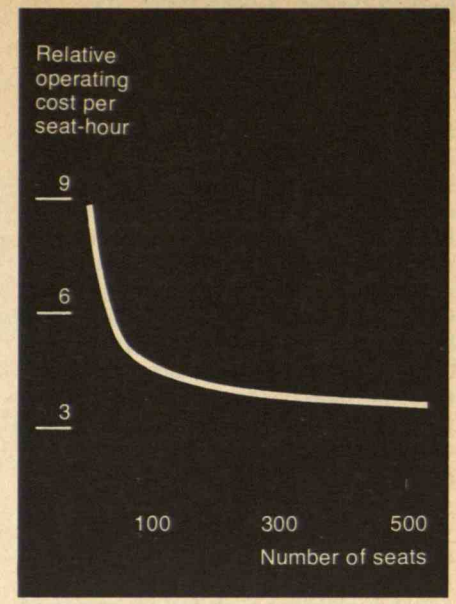
The Foggy Future of Air Transport

The air transport industry and the commercial aircraft industry which serves it are in a crosswind of uncertain demand, rising costs, new controls, and a new philosophy of deregulation. "Get ready for the great debate on transportation," advises Robert W. Simpson, Director of M.I.T.'s Flight Transportation Laboratory.

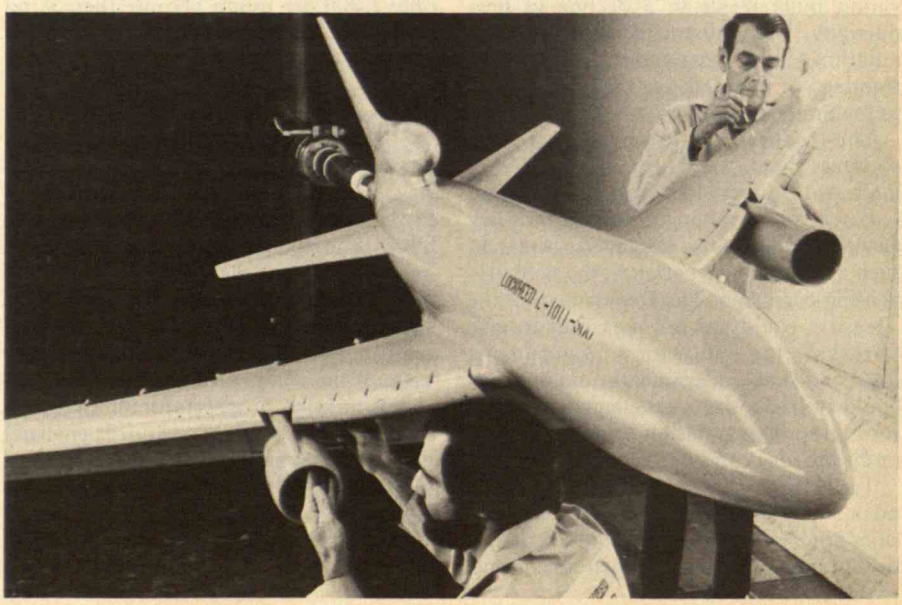
On one side, Stephen Wheatcroft, Group Planning Director for British Airways, wants to add several classes of larger, long-haul aircraft to his fleet to carry "mass tourist traffic on intercontinental routes" during the 1980s. But John E. Steiner, Vice President of Boeing Commercial Airplane Co., says the modern air traveler's demand for frequent nonstop schedules to many destinations argues against monolithic aircraft. That explains, he says, why the production of 727s and DC-10s has eclipsed that of larger 747s and 1011s, and why that trend will continue. He predicts a new emphasis on economy: fan jet engines instead of straight jets, and on-board inertial navigation instead of navigators. "With proper instrumentation on both aircraft and airways," writes Mr. Steiner, "any size of aircraft can be reliably and safely flown by two pilots."

Mr. Steiner admits that neither manufacturers nor airlines have a good record of foreseeing their future problems and markets. Professor Simpson attributes this to the many and capricious variables over which neither maker nor user of aircraft has control. Among them: public responses to airport noise problems, federal policies for imposing air traffic control costs on airlines, and the price of fuel.

Now, on top of these uncertainties, comes the Aviation Act of 1975, part of an administration effort to bring a "climate of healthy competition" into the transportation industry. It's bad news,



Are there "economies of scale" in air transportation? A crucial question in the forthcoming debate about airline deregulation, and the answer is often missed in analyses conducted at the "system" level, says Robert W. Simpson, Director of M.I.T.'s Flight Transportation Laboratory. But as with any transport unit, there is an economy of scale in transporting larger passenger loads in a given aircraft. The example above shows the effect of increasing capacity on the cost per seat-hour of operating a jet transport (1970 technology) with a design range of 1,000 miles. Data such as these lead Professor Simpson to conclude that a single carrier offering a given number of seats in a single aircraft will have costs 15 per cent less than those of three competing carriers providing similar service in smaller aircraft. Regulation is necessary to assure such a "beneficent monopoly," he writes.



Is there a new long-haul aircraft in your future? Stephen Wheatcroft of British Airways argues the need to serve "mass intercontinental tourist traffic" which he expects in the 1980s, and his company is now commissioning this new version of Lockheed's 1011 TriStar with a 6,100-mile non-stop range. But John E. Steiner, Vice President of Boeing Commercial Airplane Co., sees a future dominated by smaller jets better suited to frequent non-stop schedules to many different destinations. (Photo: Lockheed-California Co.)

says Professor Simpson: "The idea that free competition will bring both healthy competition and economic efficiency is quite false."

The key issue here is whether "economies of scale" exist in air transportation. "Deregulatory" economists tend to say no, but Professor Simpson says that this is a basic error. "A credible theory of airline economics needs to be enunciated before rational debate can take place on proposed policy and regulatory changes," he writes in *Astronautics and Aeronautics.* — *J.M.*

Fuel farms? Melvin Calvin of the University of California says the prospect is not so far-fetched. Here he inspects trees of the genus *Euphorbia,* which produce a latex sap convertible to hydrocarbons. Dr. Calvin thinks the fuel is "better than gasoline." (Photo: University of California)

ENERGY

Incentives in Saving

Half of the savings of heating oil made by Massachusetts homeowners in the dark days of the "energy crisis" in 1973-74 can be traced to such specific strategies as buying storm windows and doors, adding insulation in walls and roofs, replacing furnaces, and installing weatherstripping. Another large block of savings resulted from behavioral changes — sleeping with the windows closed instead of open, turning down thermostats, closing off unneeded rooms.

But even in homes where neither structual nor behavioral changes were made, oil consumption was down in 1973-74 — the result, apparently, of such "life-style" changes as nagging the children to close the door after letting the dog in.

In all, oil consumption by energy-conscious Massachusetts homeowners in the 1973-74 heating season was down 12 per cent — adjusted for weather — from the 1972-73 season. If you attribute all of that to the rising price of oil during and after the Arab boycott, the difference represents a demand elasticity of −17 per cent — which is to say that if the price had increased by 100 per cent, consumption would have dropped 17 per cent. (The elasticity of demand for energy is an elusive figure eagerly sought by economists; if we knew it, we would know, for example, how much tax to levy to achieve a certain reduced consumption of gasoline.)

By 1974-75 — though heating oil prices were a bit higher — no one was haunted by the spectre of literally running out of oil before the end of the winter, and heating oil consumption began to climb — to 0.189 gallon per degree-day from 0.179 the year before (compared with 0.204 in "normal" 1972-73).

All these figures apply to 700 greater Boston homes served by the Scott Oil Co. which were surveyed by Professor John J. Donovan of the Sloan School of Management and Walter P. Fischer of the M.I.T. Energy Laboratory. Their goal was to associate specific actions with specific savings, to create a model for evaluating energy conservation strategies. Among the results: storm doors save 4.4 per cent in energy consumption, storm windows (entire house) up to 11 per cent, a new oil burner (3,450-r.p.m. pump vs. 1,725-r.p.m. pump) 9 per cent.

But the important finding is that all such strategies could account for less than half of the home-owners' actual savings. Specific behavioral changes accounted for most — but not all — of the rest. The lesson for those plotting conservation strategies is clear: consumer awareness is a matter of degree, and behind every elastic demand is an elastic incentive. — *J.M.*

Grow Your Own Gasoline

There's no need to wait thousands of years for the earth to press vegetable matter into oil, says Nobel Prize-winning chemist Melvin Calvin of the University of California. Dr. Calvin has discovered a tree that produces a sap that is one-third low-molecular-weight hydrocarbon, and at a recent meeting of the American Chemical Society advanced the idea of a hydrocarbon plantation.

The trees are bushy members of the genus *Euphorbia,* all relatives of the giant rubber tree. While the latex sap that flows from rubber trees is chemically akin to petroleum, says Dr. Calvin, the molecules are too large — their molecular weight is about one million. However, the smaller members of the genus have much lower molecular weights of 10,000 to 50,000, and are more amenable to gas tanks.

Dr. Calvin's candidate for the hydrocarbon plantation is the gopher plant, now grown as a hedge in California to discourage rodents. Moles and gophers dislike the sticky sap that oozes from wounded bushes and tend to avoid it.

Acres of these cactus-like bushes could be planted in the dry areas of the Southwest, where they might produce from 10 to 50 barrels of fuel per acre each year, said Dr. Calvin. The plants are well adapted to survive on little water. They grow quickly and would continuously resprout branches removed by harvesters.

The bushes' sticky sap is "better than gasoline," according to Dr. Calvin, because it contains none of the impurities and tar appearing naturally in crude oil. Thus, burning hydrocarbon distilled from *Euphorbia* sap would reduce automobile pollution because it produces fewer by-products.

He calculates the costs of harvesting gasoline from trees to be competitive with current oil prices: a total between $5 and $15 per barrel for growing and processing the plants. He points out that the figures are only educated guesses, based on an agronomical approach used for sugar cane.

Dr. Calvin, who won the Nobel Prize in Chemistry in 1961 for his discoveries in photosynthesis of plants, foresees the possibilities of remarkable advances in breeding the plants over the next 25 years. "The green plant is the best solar harvester we have today," he says. If one could decipher and control the mechanism which determines the molecular structure of the latex, true "gasoline trees" could be grown, he predicts.

The idea of making automobile fuel from plants is not original with Dr. Calvin. The Brazilian government is now processing alcohol from sugar cane and adding it to its gasoline in small amounts to ease Brazil's acute gasoline shortage. According to Dr. Calvin, the country plans to produce a billion gallons of alcohol a year by 1980. The Brazilian government has found that today's automobiles can run on a mixture of 95 per cent alcohol and 5 per cent water if a heat exchanger is placed between the carburetor and the intake valve. Experimental vehicles thus fitted have achieved mileage and range comparable to gasoline-driven cars. — *S.J.N.*

S.O.S. from E.R.D.A.

The Energy Research and Development Administration has a bulb-shaped fluorescent light to replace an ordinary incandescent in its screw-in socket. The new bulb

uses 70 per cent less energy to produce the same amount of light as the incandescent (to light America's incandescent lamps now requires one million barrels of oil a day). And it lasts longer. But it's expensive: if produced on the basis of present technology, the fluorescent bulb would retail at $7 to $10, and E.R.D.A. doubts there's a market; so research continues.

A more practical early fruit of E.R.D.A.'s energy conservation research is a do-it-yourself insulating jacket to wrap around a domestic electric hot water heater. The cost — in kit form — is so low that a householder who installs one will be repaid by his lower electric bills in less than two years. The kit will be on the market by the end of this year.

Projects like these put E.R.D.A. in the marketing business, an unaccustomed role for most of E.R.D.A.'s engineers, says Austin N. Heller, Assistant Administrator for Conservation — using estimates of costs, pay-outs, and sales to guess at market penetrations and (partly on this basis) decide how most effectively to invest a $160 million budget for energy conservation research and development. E.R.D.A.'s principal present research is on gas-turbine- and electric-powered automobiles, "bottoming cycles" to utilize waste heat from industrial processes, a microwave-powered vacuum grain drier to replace driers using gas heaters, and high-performance batteries.

Starting up a program of this size so quickly is a tough problem — "we're looking for ideas, opportunities, and proposals," Mr. Heller told a meeting of the Massachusetts Society of Professional Engineers at M.I.T. last fall; and the gleam in his eye was reflected in some enthusiastic questions for potential helpers throughout the room. — *J.M.*

PUBLIC HEALTH

Food Additives: Debate Continues

At least 5,000 chemicals — from table salt to organics with hard-to-pronounce names — directly and indirectly enter our food supply. Some are necessary, some are cosmetic, some have been shown dangerous to public health. In the absence of complete information, how shall the consumer proceed?

"Our society could not survive without processed food," says Steven R. Tannenbaum, Professor of Food Science at M.I.T. Processed food is an historical legacy of the industrial revolution, he told a conference for 80 food editors sponsored late last summer by the *Boston Globe*. Our success as a nation depends upon the successful development of mechanized agriculture and a highly technical food processing industry, and chemical additives are essential in food processing and preservation.

James S. Turner, an attorney who is co-director of Consumer Action, Inc. (he helped Ralph Nader found his Center for the Study of Responsive Law), agreed on the need for some food additives in order to feed a hungry world. But he wants a more responsible attitude toward food processing and marketing by government and the industry — more foresight and more help for consumers who want to make better decisions. Mother's milk — one of the most basic nonprocessed resources — has been "purposely diverted and destroyed by the mechanisms that are used to sell food by this country." He refers to accusations that the promotion of baby formula to mothers in underdeveloped countries resulted in the formula's misuse and numerous infant deaths (*see* Technology Review, *July/August, 1974*).

Mr. Turner proposes that foreseeing such results of a marketing program — and therefore cancelling the program — is an industry responsibility. He advocates a market system that emphasizes information, allowing people to buy what they want and know what they're buying. Let regulators be more strict by insisting that additives be more than cosmetic — that they in fact improve food processing or nutrition. Labeling should be more specific. Instead of "artificial colors," the label would say precisely what is used in the product.

Dr. Tannenbaum agreed that consumer information is the key. For one thing, consumers need to understand the meaning of "additive." Starch added to a gravy is a food additive; so is NaCl — common table salt. Others from "natural" sources include fumaric acid, citric acid, and phosphatidyl choline, which is a form of lecithin, a constituent of all natural fats.

The food industry produces highly nutritious, clean, safe foods, said Professor Tannenbaum. But he admits that it also produces a lot of "fluffy nonsense" which supermarkets put on their shelves and call food. The "fluffy nonsense" is there, he said, because consumers buy it. "I submit that this is not the fault of the food industry any more than the urge to drive enormous automobiles is the fault of Detroit. Is alcoholism caused by the whiskey manufacturers?"

Mr. Turner places less blame on the consumer and more responsibility on federal regulatory agencies and food industries. He advocates a market system which allows people to buy what they want but which also allows them to know what they're buying. Once names are on labels, Mr. Turner foresees the possibility of intelligent discussion of individual additives and products. The people could more intelligently decide what they wanted and companies would respond, he believes. — *Sandra Knight*

Rumors of Deadly Vegetables

It's recently been a bumpy road for those souls on the "natural-is-always-better" bandwagon. Some "natural" foods would have been banned long ago had they been man-made, according to Elizabeth K. Weisburger, researcher at the National Cancer Institute.

Before the 1960s, she told an audience at the American Chemical Society meeting this fall, "natural" products were considered safe by the Food and Drug Administration, but as soon as cancer researchers began testing a wide variety of substances, notions changed quickly. One of the first "natural" products to come under fire was safrole. This flavoring agent, formerly used in root beer, reportedly causes liver tumors in rats when administered in large doses. In the last 15 years the list of plants to be avoided has grown to include some surprising members:

— Golden ragwort, or *Senecio aureus,* is an aster-like weed known to be poisonous to domestic animals. The plant stays green after the first frost, appealing to grazing animals. The plant contains pyrrololizidine alkaloids which block the liver's ability to turn the body's waste ammonia into excretable products.

— Tarragon yields an oil used to flavor vinegar and to scent perfume. The oil contains estragole, a compound found by University of Wisconsin researchers to cause liver tumors in mice.

— Fiddleheads, or bracken fern, often eaten as a springtime delicacy, are reported to cause bladder cancer in animals which graze upon them. The chemical compounds in the fern which cause disease have not yet been identified.

— And, of course, tobacco, a weed needing no further identification, produces numerous cancer-causing products when it is burned. Dr. Weisburger attributes to cancer researcher, Michael Shimkin, the comment, "If tobacco were spinach, it would have been banned long ago."

Except for tobacco, data linking such natural substances to human disease is lacking. Dr. Weisburger advises that a moderate, nutritious, and varied diet is the best protection against these "natural" poisons. — *S.J.N.*

Can Good Health Be a Human Right?

Laboratory research has contributed immeasurably to the development of vaccination, immunization, and antibiotics, and so we tend to expect that every disease can have a specific cure. But Robert S. Morison, who recently retired as Director for Medical and Natural Sciences of the Rockefeller Foundation, suggests that today's major medical problems are different — and that therein lies a lesson for those who propose ever-greater investments in traditional systems of health care and its delivery.

Most cancer and heart disease, which now account for over two-thirds of all deaths, are clearly associated not with disease but with lifestyle — with habits of smoking and alcoholism, for example, and with a way of life that fosters tensions between the individual and society. Such problems respond more to prevention than to cure, but unfortunately medicine in the U.S. has never had much leverage on changing people's habits.

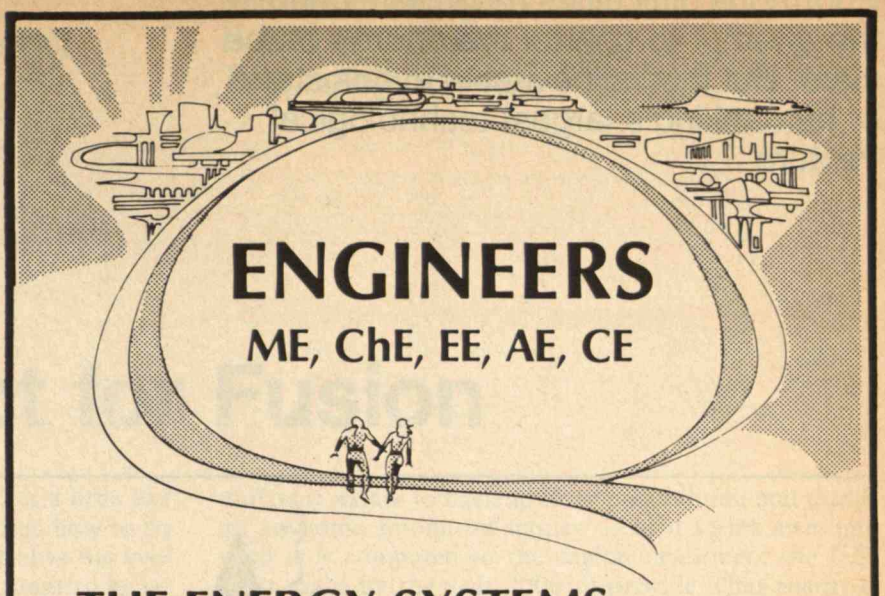
Three other paradoxes further complicate the path toward equitable health care in the U.S., said Dr. Morison at an M.I.T. seminar last spring (Dr. Morison is now Class of 1949 Visiting Professor at the Institute):

— When one disease is conquered, another must inevitably replace it as the prime cause of suffering and death. This new disease will be harder, more costly, perhaps impossible to conquer.

— The things that medicine does best cost least. Smallpox, polio, malaria, and cholera, for example, can be conquered with a few dollars' worth of antibiotics. But such expensive procedures as organ transplants are often of doubtful value, "especially if the quality of life is taken into account," said Dr. Morison. A corollary is that "most doctors spend most of their time doing things that don't accomplish much good." This is because effective treatments are likely to be simple and quick, and patients with complex, chronic conditions for which help is difficult, perhaps impossible, demand most attention.

— Modern medical education is directed toward "the scientific approach that has made medicine so successful in reducing mortality rates" rather than "what the doctor spends most of his time doing" — that is, relieving the discomforts, stresses, and poorly defined discomforts of everyday life.

All these things are rooted in the human side of medicine, and all contribute to the pattern of diminishing returns for each increment in the cost of medical services. A more equitable distribution of health services will not resolve these frustrations; the real need may be a complicated set of social, economic, and psychological changes which affect our prevailing view that unlimited access to health services is a human right. — *J.M.*



ENGINEERS

ME, ChE, EE, AE, CE

THE ENERGY SYSTEMS THEY'LL USE IN 2001 COULD BE THE SYSTEMS YOU DEVELOPED WITH US.

As a major diversified corporation with a long history of engineering "firsts," we're looking to the future again.

We're staffing a totally new, high technology effort that will focus on coal gasification, fossil fuel and solar energy. And, we're forming a nucleus of imaginative engineers who can investigate these emerging energy sources and explore the long term possibilities.

Initial objectives will be the identification of energy products we can develop, as well as the areas of expertise —such as program management and engineering systems— that can make us a leader in this field, as we are in so many others. Further responsibilities will include the creation of pilot programs that can take existing technology and apply it to new hardware development and test.

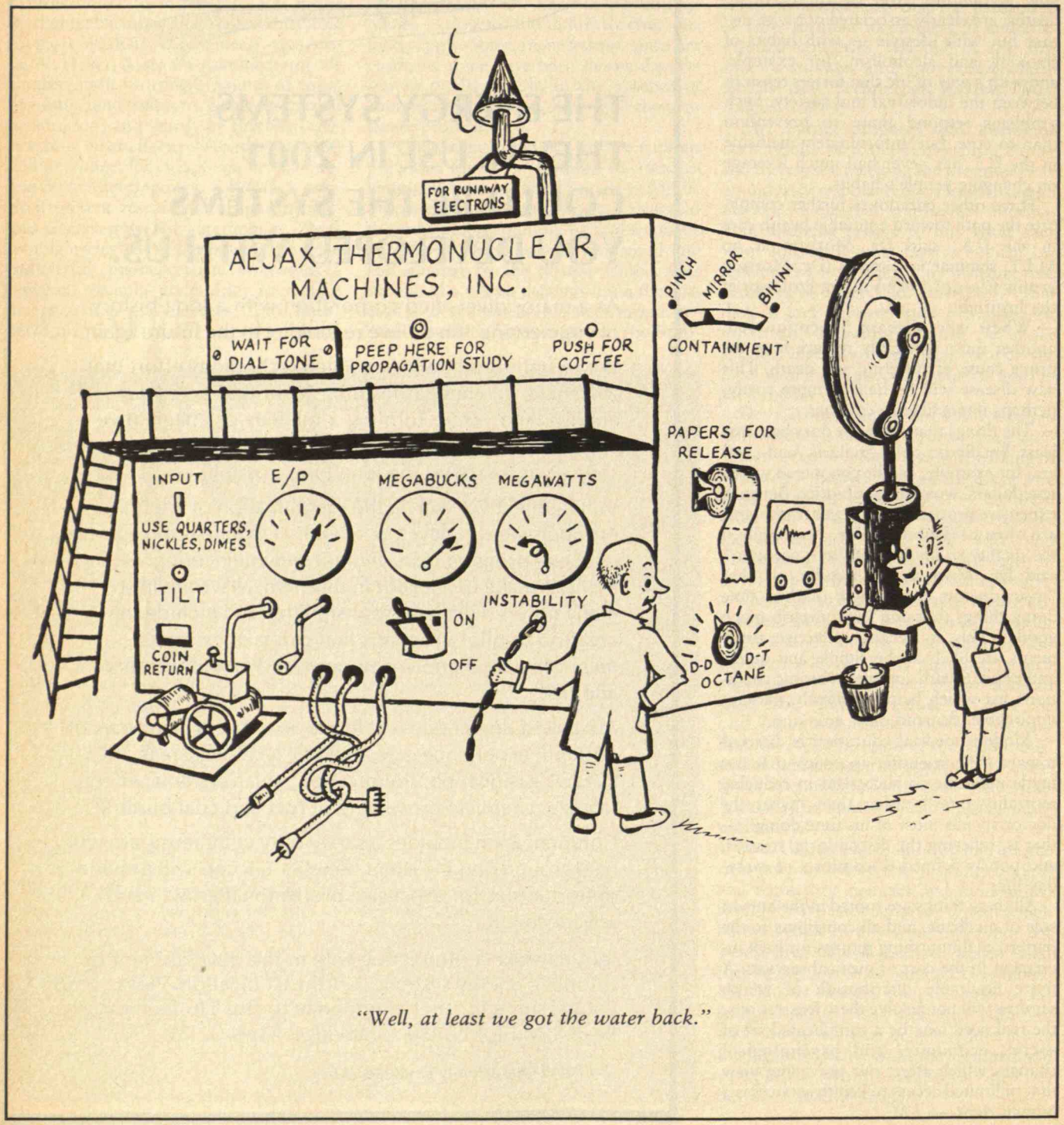
Advanced degrees are preferred with five to ten years of in-depth experience in several key technical areas, such as coal gasification, liquification, solar systems, energy storage, chemical processing of fuel and coal burning.

Compensation includes a salary fully commensurate with background plus excellent benefits. Success will provide opportunities for expansive professional growth and advancement.

Join us—take a pioneering role in the development of futuristic energy systems. Northeast location. Please send your resume in strict confidence to Box 126, Technology Review, M.I.T., E19-430, Cambridge, Mass. 02139

An Equal Opportunity Employer (M/F)

Enormous difficulties have developed in the attempt to control the energy of the stars. But that is inevitable at this stage of humankind's largest technological venture



"Well, at least we got the water back."

David J. Rose
Professor of Nuclear Engineering
M.I.T.

Michael Feirtag
Board of Editors
Technology Review

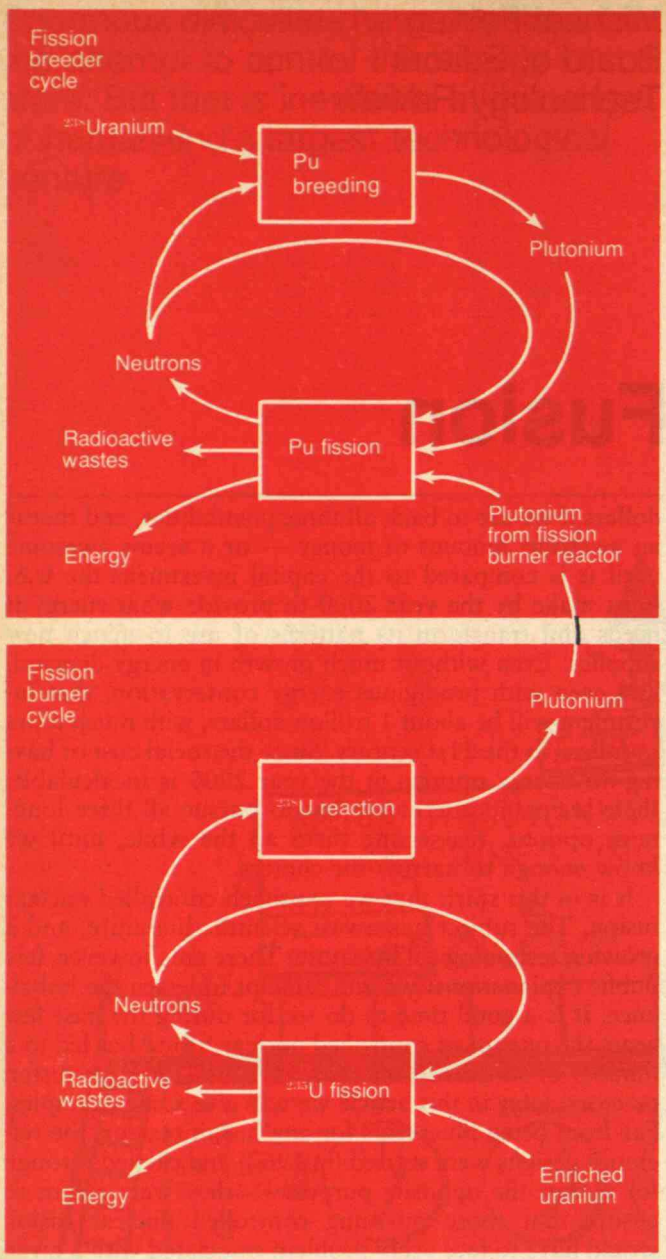
The Prospect for Fusion

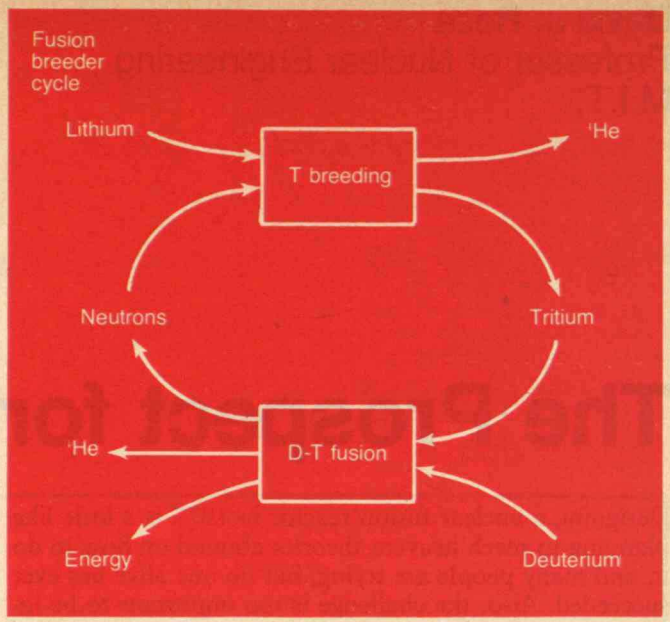
Designing a nuclear fusion reactor in 1977 is a little like planning to reach heaven: theories abound on how to do it, and many people are trying, but no one alive has ever succeeded. Also, the challenge is too important to be ignored — in fusion's case because we are running out of energy. In the short term, for perhaps 25 years, there will be oil. For 50 to 100 years after that, we could fight over the last available drops of oil and burn increasing quantities of coal, probably at great environmental cost. But after that — and preferably before — humankind will have to turn to one or more of the long-term options that nature holds before us. There are only three. One is solar power. A second is nuclear fission — or, more specifically, since rich fissionable material also grows scarce, the development of a so-called breeder reactor that creates more fissionable fuel than it consumes. The third is nuclear fusion. At present, none of these options is sure to work. Each possesses remarkable and perverse difficulties. To bring any one of them to a point where society can decide whether or not to adopt it as a principal energy resource will cost 10 to 20 billion dollars. To develop alternatives within an option (an alternative breeder, for example) will cost an additional 1 or 2 billion dollars for each new possibility. In short, we are compelled to play a desperate poker game against nature in which each betting chip costs tens of billions of dollars, and thus far we fear to buy the chips. After all, one can imagine the spending in this game of 60 to 100 billion dollars if we are to back all three possibilities, and that is an awesome amount of money — or it seems awesome until it is compared to the capital investment the U.S. must make by the year 2000 to provide what energy it needs and transform its patterns of use to match new supplies. Even without much growth in energy demand, and even with prodigious energy conservation, that investment will be about 1 trillion dollars, with much more to follow in the 21st century. Since the social cost of having *no* energy options in the year 2000 is incalculable, there seems no alternative but to pursue all three long-term options, reassessing them all the while, until we know enough to narrow the choices.

It is in this spirit that we approach controlled nuclear fusion. The subject has a vast scientific literature, and a growing technological literature. There are, however, few public explanations; we will attempt to lessen the imbalance. It is a good time to do so, for during the past few years the pursuit of controlled nuclear fusion has led to a number of so-called "reference designs" for large fusion reactors; later in this article we will give some examples. Far from being blueprints for any fusion reactor, the reference designs were started (in 1967) and carried through for almost the opposite purpose — they were meant to ensure that those pursuing controlled nuclear fusion would have to face every problem associated with a given reactor concept. Thus the designs were problem-finders, not problem-solvers, and as such they were spectacular successes. From the tortured and sometimes bizarre schemes to which the researchers were compelled to resort, long lists emerged of scientific and technological areas needing attention: more radiation-resistant alloys, different systems for cooling the reactor, higher energy-handling ability per unit area of reactor wall, and so forth. Their purpose being accomplished, the current reference designs are now being discarded as their makers turn to the critical problems, and new reference designs in due course should appear. The making of reference designs that uncover problems, and the development of technologies that solve them, are activities that proceed more or less continuously; and if, years from now, the fusion program succeeds, designs will appear for a practical fusion reactor probably unlike anything now envisaged.

But will it succeed? Is civilization mad to persist in a search that seems so complex, so uncertain? The science and some of the technology have progressed to a point where many questions of a decade ago — for example, "Is controlled fusion scientifically feasible?" — now appear obsolete; they have been answered affirmatively as a

Professor Rose made this drawing in 1958; it was meant to adorn the program for the annual Gaseous Electronics Conference of the American Physical Society, but the Program Committee suppressed it. Now, after 18 years, we try again. In 1958, research on controlled fusion had just been declassified. The public was told that its advent was imminent. Yet even then, many problems were recognized. "E/P" represents the ratio of electric field to pressure; it is a parameter crucial to the creation of a plasma — a gas of charged particles. "Instability" is short for plasma instability: in 1958, one of the most dreaded varieties was the so-called sausage instability, in which a plasma column pinches off at intervals, and bulges in-between. "Propagation" is that of electromagnetic waves; they bear upon the successful confinement of a plasma. Other features of the Aejax Machine will be made clear in the text. The drawing's caption refers to a selling point (then and now) for controlled fusion: the prospect that a fusion reactor will be fueled by a mixture of deuterium (D) and tritium (T) — both isotopes of hydrogen. The former, at least, is in essentially endless supply, for it is a component of ordinary water.





Left: The fuel cycle for nuclear fission. It begins in the lower box, where uranium enriched in its content of ^{235}U fuels a burner reactor — a reactor with a net consumption of fissionable material. Nearly all uranium is ^{238}U, which cannot fission. Some of it, however, is transformed in the reactor to plutonium, which *can* fission. If sufficient Pu is stockpiled, and if a second type of reactor, a so-called fast breeder, becomes available, then the fuel cycle will enter the upper box. Here, ^{238}U becomes the fuel. Plutonium is both bred and burned. The link with the burner cycle can now be severed, and fission can persist as an energy source through a far longer technological age.

Above: The fuel cycle for nuclear fusion. Deuterium, an isotope of hydrogen, is harvested from ordinary water. Tritium, a second hydrogen isotope, does not occur in nature; it must be bred from lithium, much as plutonium is bred from ^{238}U. A mixture of deuterium and tritium nuclei is the most workable fuel for fusion; the conditions required to fuse other light nuclei are far more extreme.

byproduct of the race to develop ever larger experiments. On the other hand, the technological and engineering difficulties are now known to far surpass any original estimates; still another decade or two will be needed to resolve them, and decide about fusion, pro or con. In the meantime, fusion's expanding success coupled with its increasingly evident difficulty will remain a hard mixture to manage; it could easily inspire false optimism or false pessimism — and, either way, wrong judgments. Responsibility for keeping a proper sense of perspective falls primarily upon the Energy Research and Development Administration, the patron of controlled fusion research in the U.S — it costs so much that no organization but the federal government can afford to sponsor it. E.R.D.A.'s inclinations, coupled with the prospect of support, could stimulate its clients, the National Laboratories and other research organizations, to adopt a sycophantic, or at least a neutral, stance. When false certainty grows, so critical judgment withers. The true development effort suffers.

How might it happen? The answer is: bit by bit, and with the best of intentions. Administrators, overcome by the temptation of so much to administer, may mistake vision for reality. Engineers, meanwhile, may become expert at their task, and neglect to maintain constructively critical attitudes. After all, it is human nature to assume that some fault in a grand conception will be solved by future ingenuity, and it is easy to allow a design to become a neat assemblage of what engineers call black boxes. In these ways, an inadequate design becomes the accepted design, and finally the official program, attracting to itself all the support and funding that exists. The public is led to believe that technological salvation is imminent. It then develops that the design is unworkable and the program ends in disaster. An exemplar exists of this sort of calamity. Several years ago, the liquid metal fast breeder reactor almost choked on administrative rigidity and money — not because that breeder reactor is a bad (or a good) idea, and certainly not because those in charge of the program planned it that way. It just happened. . . And whether the same thing may now be happening to controlled nuclear fusion is a topic we will return to at the end of this article.

Energy Technology for the 21st Century

Several lines of thought converge when one contemplates controlled fusion. The first line concerns energy needs in the next century, and the schemes proposed to satisfy them. The second concerns the timetable on which fusion might be developed, if it is to find a place in 21st-century technology. The third concerns the question of how new and very complex technologies should be created.

Regarding the first line of thought — future energy needs — opinions vary about the quantity of exploitable fossil-fuel reserves on this earth, but several things are clear. First, the indigenous petroleum and natural gas resources available to most developed countries are either negligible or increasingly expensive. The large reserves in the Mideast and the U.S.S.R. will be mostly used up (or at least committed) early in the next century, even if energy use grows at a rate somewhat less than the present world-wide rate of five per cent per year. Second, the rise in fossil fuel prices to consuming nations — now by cartel action, and surely in the future whether a cartel operates or not — will continue to make nuclear fission power a relative bargain throughout the developed world — a fact of profound significance to the future of fusion, as we shall soon see. Finally, the rational and sparing use of energy, often called conservation, can bring about substantial savings; predictions of 30 per cent or even more seem borne out by experience during the 1973-74 winter; but those savings, however welcome from many viewpoints, can only moderate and cannot remove the prospects of supply difficulty ahead.

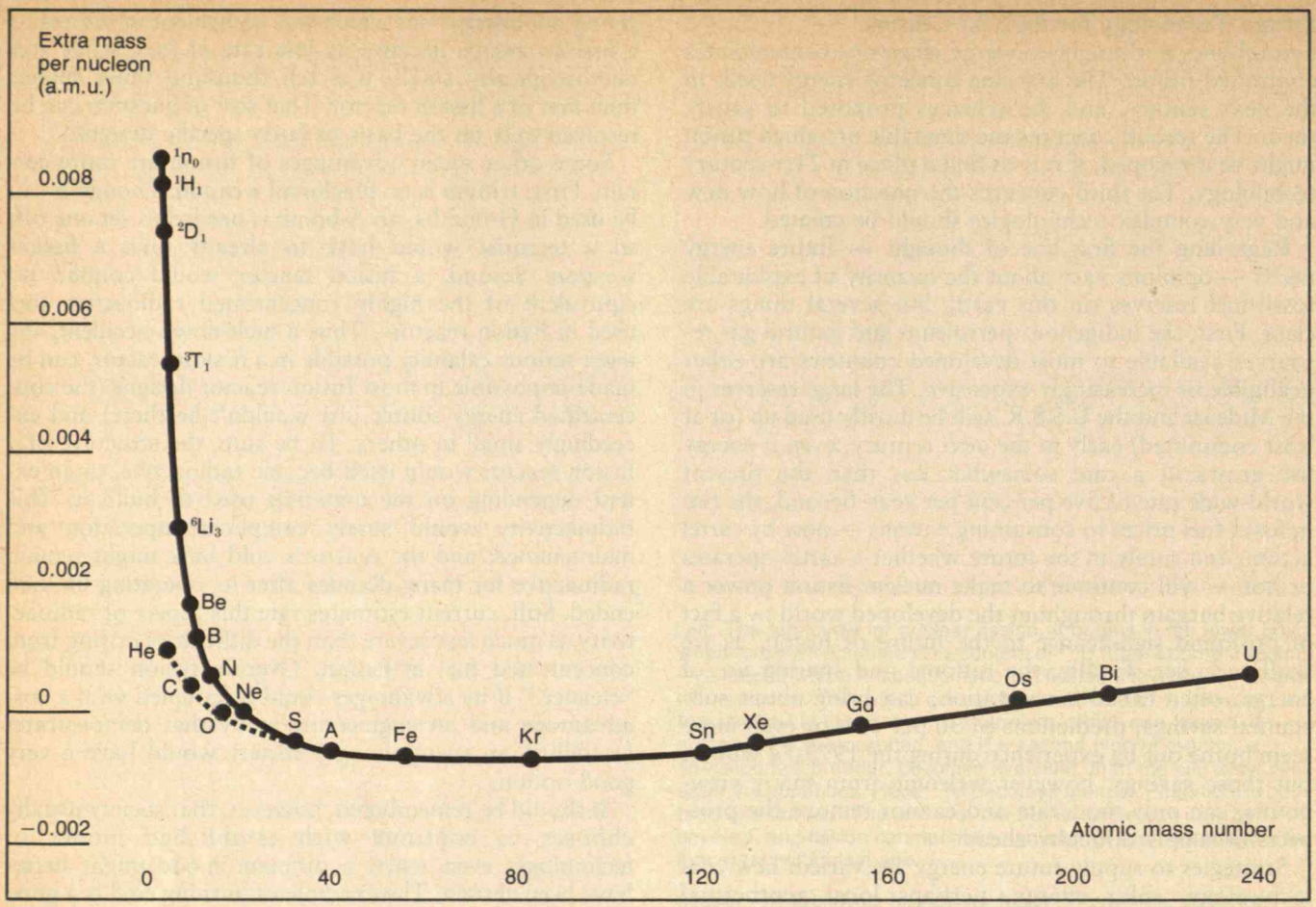
Strategies to supply future energy are varied: new coal technology, solar energy, perhaps local geothermal energy, accelerated and advanced nuclear fission technology, fusion. All have a long leadtime, both for development and deployment, and most could last for relatively long periods of time if they are deployed at all. New technologies expected to be extensively deployed early in the next century must be fully developed by the end of this century; thus the main technological lines should be clear and the main difficulties resolved by 1985 or 1990. Advanced fission power systems, including breeder reactors, are being developed in approximate accord with this schedule. Because of fission's cost advantage (relative to fossil-fuel electric power) in most locations, even if uranium prices should rise severalfold, arguments of resource limitation will not apply to nuclear power unless an acceptable breeder reactor cannot be developed by the early 21st century. Thus, barring a public decision against it, nuclear power could be well developed and well installed before the end of the century.

Against this specific situation and on this time scale, fusion must offer some real advantage if it is to supplant advanced fission systems. What then are the benefits? Part of the fuel for a fusion reactor will be tritium — a radioactive isotope of hydrogen. Fortunately, tritium is vastly less hazardous than uranium fission products or than plutonium, per unit of energy produced by nuclear reactions, or simply per unit weight. Exactly how much less depends upon the particular route by which the radioactive material is imagined to invade the human body — whether it enters by ingestion, inhalation, and so on. Analysts speak of it being a factor of a thousand or ten thousand less hazardous. Countering that is the fact that such hazards are not solved by merely stating them in simplistic terms. One can imagine a fusion reactor that would work perfectly well, in the technological sense of giving out energy, but which was equivalent in hazard to a fission reactor because its loss rate of fuel, while still microscopically small, was ten thousand times higher than that of a fission reactor. That sort of question can be resolved only on the basis of fairly specific designs.

Some other social advantages of fusion are more certain. First, tritium is no blackmail weapon. Though it can be used in H-bombs, an A-bomb is needed to set one off, so a terrorist would have to already own a fission weapon. Second, a fusion reactor would contain no equivalent of the highly concentrated radioactive fuel used in fission reactors. Thus a melt-down accident, the most serious calamity possible in a fission reactor, can be made impossible in most fusion-reactor designs (the concentrated energy source just wouldn't be there) and exceedingly small in others. To be sure, the structure of a fusion reactor would itself become radioactive, to an extent depending on the materials used to build it. This radioactivity would surely complicate operation and maintenance; and the reactor's cold hulk might remain radioactive for many decades after its operating life had ended. Still, current estimates rate this aspect of radioactivity as much less severe than the difficulties arising from concentrated fuel in fission. Overall, fusion should be "cleaner." If its advantages could be coupled with a cost advantage and an engineering study that demonstrates feasibility, an energy-hungry society would have a very good option.

It should be remembered, however, that society usually chooses to continue with established modes of technology, even when a different mode might better have been chosen. The example of burning coal is a good one: about 50 years ago, the technology of turning coal into powder, blowing it into a combustion chamber, and burning it was developed; but the alternate technology of burning it in a fluidized bed was not far behind. The powdered-coal technology won; and even though the very large environmental costs of sulfur oxides and particulates associated with this technology have been recognized for years, fluidized bed combustion is only gradually and grudgingly being reconsidered now. So it could be with fusion. Public perception currently places the hazards of fission very high; and if those hazards are seen to be smaller, fusion will lose some of its social attraction. Moreover, if an acceptable breeder reactor is developed (including means for fuel reprocessing, waste disposal, and preventing antisocial use), then the prospect for fusion will further decline. So would the prospect for solar power, about which we are less hopeful for large-scale electric installation, but that is another story.

This debate brings us well into the second line of thought: the timetable for fusion development. To offer a meaningful alternative to fission, fusion should aim for approximately the same time scale — principal engineering problems seen to be resolvable before 1990, say. That is a very short time for a task so large, too short for scientific, technological, and economic feasibilities to be established in conventional and orderly sequence. The various stages must partly overlap and coalesce, so that technology and engineering known to be needed are worked on now. This is the rationale for the reference designs: groups persistently try to design fusion reactors, based on the latest science and technology, then analyze the designs to uncover their shortcomings. From that activity, clues appear about the next set of problems to be studied, and also about what direction large experiments



The mass of a nucleon — a neutron or a proton — in the nuclei of the various chemical elements. By convention, the ^{16}O nucleus is taken to have a mass of 16 a.m.u. (atomic mass units), and other nuclei are then compared with it. It is found that free neutrons ($^1n_0$ in the chart) and free protons ($^1H_1$ nuclei) have more mass than any neutrons and protons bound within nuclei. This means that when the chemical elements formed, mass disappeared. It became energy, in accordance with $E = mc^2$. The nucleons in the middle-atomic-weight elements — iron (Fe) and krypton (Kr), for example — lost the most mass. Such elements are therefore the most stable: any rearrangement of their nucleons requires energy. On the other hand, breaking up the heaviest nuclei into lighter ones releases energy; this is nuclear fission. So does the combination of the lightest nuclei into heavier ones; and this is nuclear fusion.

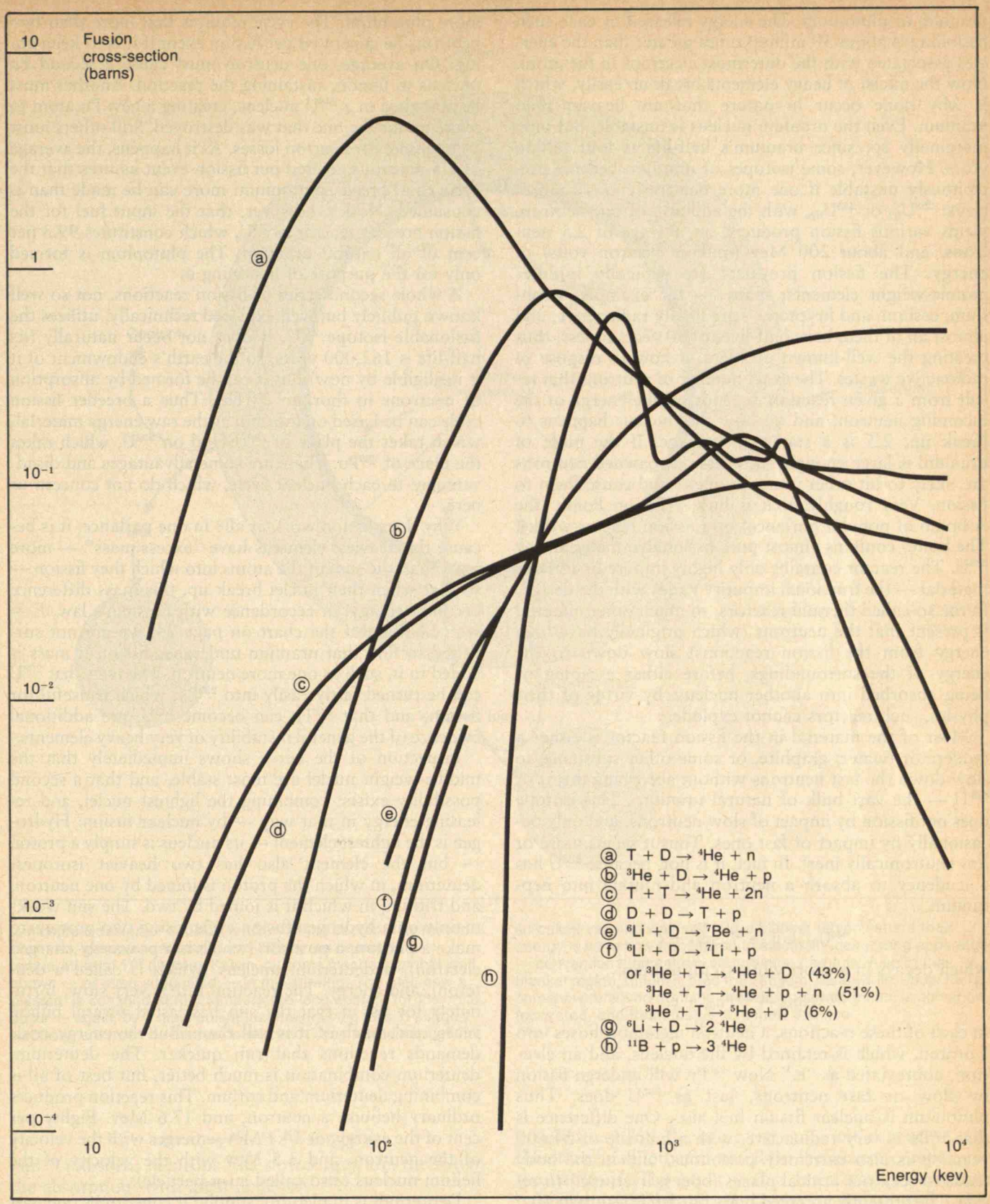
should take. If all the problems prove to be tractable, the whole effort will culminate in a well-worked-out fusion concept by the late 1980s, ready for trial on a grand scale.

This leads us to the third major line: how to do the job. Development of any difficult modern technological devices, including fusion reactors, tends to suffer from excessive disciplinary reductionism: any single group concerned with only one phase of the work tends to use up all the design flexibility to solve its own problems, thus leaving impossible tasks for everyone else. Each discipline appropriates to itself all the available option space, so to speak. In illustrative exaggeration, we note that the development of fusion concepts has been mainly in the hands of physicists until almost the present time, so controlled fusion has been looked upon mainly as a research problem — specifically, as a matter of confining a plasma (a gas of charged particles). Such physics-oriented research was conducted under the naïve assumption that technology (the development of new materials and processes) and engineering (the application of technology to socially desirable purposes) could do anything necessary to make a plasma that precisely suited the plasmologist's fancy. But technology and engineering cannot be conjured up at will; and in fact, they are usually very expensive to extend in any new directions. Thus the need for balance from the start. The three major constraints of "plasma dynamics," technology, and engineering must be jointly satisfied if there is to be a happy outcome to the search for fusion.

Energy from the Nucleus

The idea of controlled nuclear fusion is not new. Ever since the 1930s, when the sun's nuclear cycle was first worked out in detail, people have speculated about the possibility. However, nothing was accomplished until World War II, when the Manhattan Project set out to build what is commonly called an "atomic bomb," a name which is somewhat misleading. It should be called a nuclear bomb, for "atomic" refers to the whole atom — that is, to the nucleus and the surrounding electrons. An atom may be ionized (it loses one or more of its electrons and thereby becomes positively charged), but the energies involved are modest, on the order of a few electron volts.

Interactions within the nuclei are vastly more energetic; the Manhattan Project developed bombs operating on the principle of breaking up, or fissioning, the nuclei of



Several fusion reactions of interest to an energy-hungry society. The horizontal axis plots particle energy, in electron volts (ev). The vertical axis plots the so-called reaction cross-section, a measure of how close two nuclei must come in order to fuse. For the vertical axis, the units are "barns," where each barn is 10^{-24} square centimeters. The fusion of deuterium and tritium is easiest to manage: 20-kev (20,000 electron volt) deuterium and tritium nuclei have, from the chart, a fusion cross-section of about 0.1 barn. However, a gas with an average energy per particle of 20 kev includes a considerable number of more energetic particles, and their fusion cross-sections (up to 5 barns) raise the average for the whole group to about 1 barn. It follows that the deuterium and tritium nuclei in a fusion plasma at 20 kev must approach to within a distance of about 10^{-12} centimeters (the radius of a circle 10^{-24} square centimeters in area). One other reaction on the chart — that of boron-11 with a proton — is noteworthy, for it produces no radioactivity and also no neutrons to pass through a reactor wall and damage outside structures. But a million ev is required to start the reaction, making boron-proton fusion remote in humanity's future.

uranium or plutonium. The energy released by each such fissioning is about 50 million times greater than the energies associated with the outermost electrons in the atom. Now the nuclei of heavy elements break up easily, which is why none occur in nature that are heavier than uranium. Even the uranium nucleus is unstable, but only marginally so, since uranium's half-life is four billion years. However, some isotopes of uranium become precipitously unstable if one more neutron enters the nucleus: $^{233}U_{92}$ or $^{235}U_{92}$, with the addition of one neutron, yields various fission products, an average of 2.5 neutrons, and about 200 Mev (million electron volts) of energy. The fission products are typically middle-atomic-weight elements; many — for example, strontium, cesium, and krypton — are highly radioactive, and almost all of them have half-lives of 30 years or less, thus creating the well-known problem of how to dispose of radioactive wastes. The exact number of neutrons that result from a given reaction depends on the energy of the incoming neutron, and on how the nucleus happens to break up; 2.5 is a statistical average. If the piece of uranium is large enough, these fission-spawned neutrons are likely to hit other uranium nuclei and cause them to fission. Very roughly, that is how a fission bomb (the A-bomb of popular parlance) or a fission reactor works. The bomb contains almost pure fissionable material, say ^{235}U. The reactor contains only highly impure fissionable material — the fractional impurity varies with the design. In the so-called thermal reactors, so much other material is present that the neutrons (which originally have high energy from the fission reactions) slow down to the energy of the surroundings, before either escaping or being absorbed into another nucleus. By virtue of their physics, such reactors cannot explode.

Most of the material in the fission reactor is either a moderator (water, graphite, or some other substance to slow down the fast neutrons without absorbing them) or ^{238}U — the vast bulk of natural uranium. This isotope does not fission by impact of slow neutrons, and only occasionally by impact of fast ones. Thus it seems more or less neutronically inert. In fact, it is not, because ^{238}U has a tendency to absorb a neutron and mutate into neptunium,

$$^{238}U_{92} + n \rightarrow {}^{239}Np_{93} + e$$

which decays in a short while to plutonium,

$$^{239}Np_{93} \rightarrow {}^{239}Pu_{94} + e$$

In each of these reactions, a neutron metamorphoses into a proton, which is retained by the nucleus, and an electron, abbreviated as "e." Now ^{239}Pu will undergo fission by slow or fast neutrons, just as ^{235}U does. Thus plutonium is nuclear fission fuel also. One difference is that ^{239}Pu is very radioactive, with a half-life of 24,600 years. It is also extremely poisonous, and in the body tends to seek out critical places (bones, liver, etc.) to reside. The presently accepted body burden is less than 10^{-6} grams. On the other hand, ^{235}U is hardly radioactive at all, so its chief hazard is as a chemical poison. However, in nature it is often accompanied by the uranium decay products radium and radon, and in a nuclear reactor it becomes mixed with highly radioactive fission products.

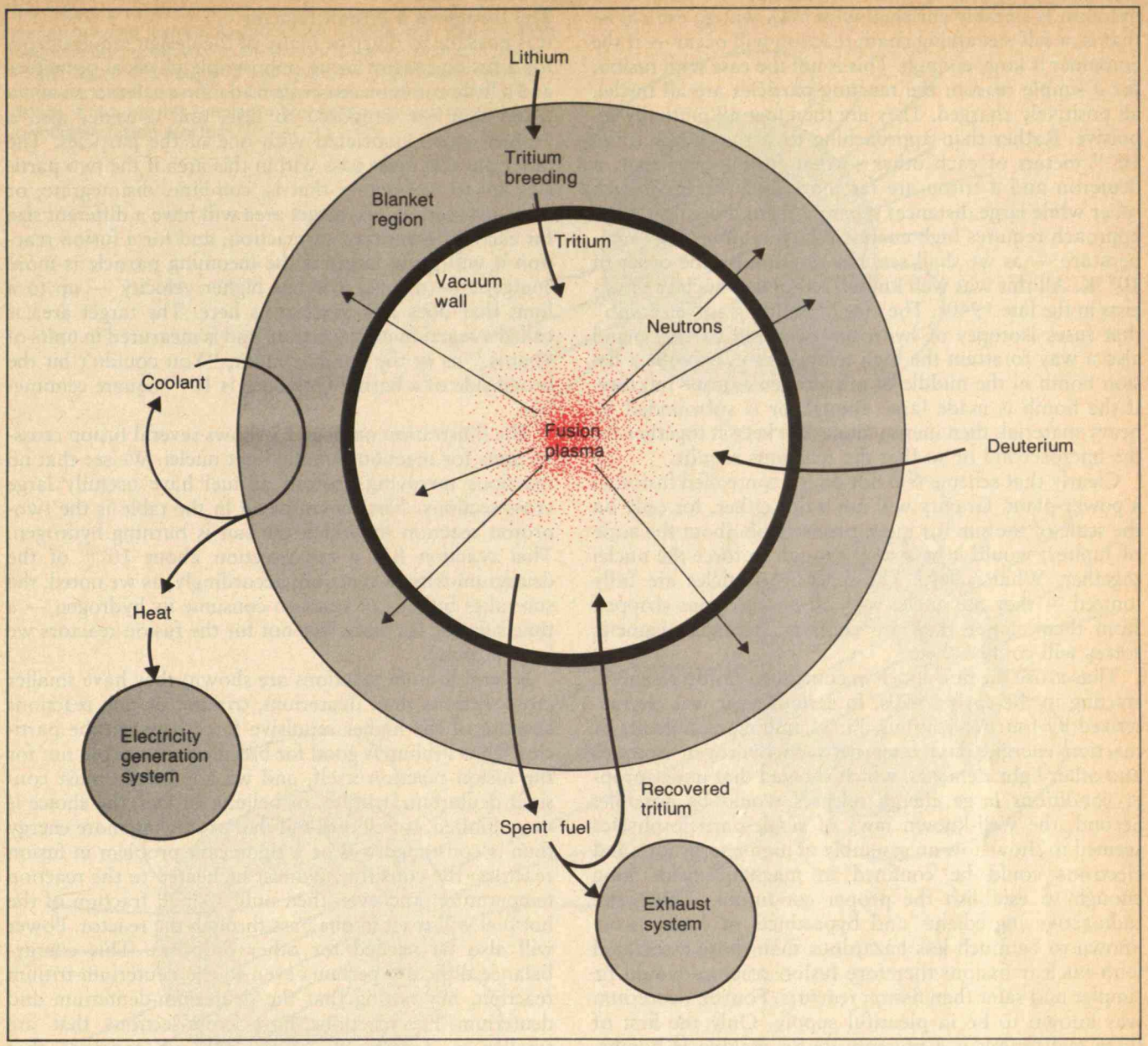
The creation of plutonium is the phenomenon that makes so-called "fast breeder" reactors possible. One starts with plutonium (made in a conventional "burner" reactor) and fissions it in the presence of ^{238}U to make more plutonium. The cycle requires that more than two neutrons be generated per fission event if it is to keep going: On average, one neutron must cause a second Pu nucleus to fission, sustaining the reaction. Another must be absorbed in a ^{238}U nucleus, creating a new Pu atom to make up for the one that was destroyed. Still others must compensate for neutron losses. As it happens, the average of 2.5 neutrons created per fission event assures that the cycle can "breed" plutonium: more can be made than is consumed. Notice, however, that the input fuel for the fission breeder reactor is ^{238}U, which constitutes 99.3 per cent of all natural uranium. The plutonium is formed only for the purpose of fissioning it.

A whole second series of fission reactions, not so well known publicly but well explored technically, utilizes the fissionable isotope ^{233}U. It does not occur naturally (its half-life is 162,000 years, so the earth's endowment of it is negligible by now) but it can be formed by absorption of neutrons in thorium (^{232}Th). Thus a breeder fission cycle can be based on thorium as the raw energy material, which takes the place of ^{238}U, and on ^{233}U, which takes the place of ^{239}Pu. There are some advantages and disadvantages to each nuclear cycle, which do not concern us here.

Why does fission work at all? In one parlance, it is because the heaviest elements have "excess mass" — more mass than the sum of the atoms into which they fission — so that when their nuclei break up, this mass difference becomes energy, in accordance with Einstein's law, $E = mc^2$. Looking at the chart on page 24, we are not surprised to find that uranium undergoes fission if mass is added to it, such as one more neutron. The facts that ^{238}U can be turned fairly easily into ^{239}Pu, which is useful for fission, and that ^{232}Th can become ^{233}U, are additional evidence of the general instability of very heavy elements.

Inspection of the curve shows immediately that the middle-weight nuclei are most stable, and that a second possibility exists: combining the lightest nuclei, and releasing energy in that way — by nuclear fusion. Hydrogen is the lightest element — its nucleus is simply a proton — but the element also has two heavier isotopes: deuterium, in which the proton is joined by one neutron, and tritium, in which it is joined by two. The sun works mainly on a hydrogen fusion cycle, using two protons to make a photon, a positron (which is a positively charged electron), a deuterium nucleus (which is called a deuteron), and energy. The reaction rate is very slow, fortunately for us, in that the sun has lasted several billion years, and much of it is still there. But the energy crisis demands reactions that run quicker. The deuterium-deuterium combination is much better, but best of all is combining deuterium and tritium. This reaction produces ordinary helium, a neutron, and 17.6 Mev. Eighty per cent of the energy, or 14.1 Mev, emerges with the velocity of the neutron, and 3.5 Mev with the velocity of the helium nucleus (also called an α-particle).

Deuterium is in plentiful supply; it constitutes one part in 7,000 of the hydrogen in ordinary water. Since there are some 150×10^6 cubic miles of water in the oceans, the amount is prodigious, enough in fact to last for billions of years, even at the highest rate at which we can use energy without overheating our environment. The problem comes with tritium: it is radioactive, with a half-life of 12.3 years, so it does not occur in nature. Fortunately, the two isotopes of lithium can be used to make it. High-energy neutrons (above 2.5 Mev) can react with ^{7}Li:



Conceptual design of a fusion reactor. At the center of its reaction chamber, gaseous deuterium and tritium are heated to a temperature of 10^8 degrees Kelvin, by some mechanism that isn't shown — or even suggested — in the drawing. The gas, now a plasma, is confined at that temperature long enough for fusion to occur — again, by a mechanism that the drawing fails to suggest. Neutrons are freed by the fusion reaction. They speed through the so-called vacuum wall and into a blanket region, where their energy is somehow transferred to electricity-generating apparatus — conventional steam-driven turbines, perhaps. Also in the blanket region, tritium is bred from lithium. Meanwhile, spent fuel is somehow removed from the reactor, unburned tritium is somehow recovered, and fresh fuel is somehow injected.

$$^7\text{Li} + \text{n[fast]} \rightarrow {}^4\text{He} + {}^3\text{T} + \text{n [slow]}$$

and ^{6}Li absorbs neutrons (the slower they are, the better the absorption) with great appetite:

$$^6\text{Li} + \text{n} \rightarrow {}^4\text{He} + {}^3\text{T} + 4.8 \text{ Mev}$$

Thus we have a generation scheme for tritium. Note the parallel with a fission *breeder*. A fusion reactor is in fact a breeder: it uses deuterium and lithium as raw fuels, and breeds tritium as an intermediate product that is burned in the reaction. Because only a single neutron appears per fusion event, one might imagine that fusion cannot work: the losses would not let the tritium reproduce itself. Not so, because the two lithium reactions can in principle proceed sequentially, using the same initial neutron. On the other hand, other materials in the reactor compete for the neutrons. The result is that fewer than two tritons (tritium nuclei), on average, can be created for each triton destroyed. Still, tritium can be more than replenished.

A second problem now appears. Fission is an easy thing (given some fissionable material) because a neutron is electrically neutral, so it can enter the positively-charged nucleus without encountering any repulsive force. Thus uranium and neutrons can be at room temperature, and yet the uranium will fission, atom by atom, and the fission energy can be turned into heat, say to boil water. In fact, a water solution of some uranium salts, in which the

uranium is suitably enriched with ^{235}U, will go critical — that is, a self-sustaining chain reaction will occur — if the container is large enough. This is not the case with fusion, for a simple reason: the reacting particles are all nuclei, all positively charged. They are therefore all mutually repulsive. Rather than approaching to within a few times 10^{-15} meters of each other so that fusion can occur, a deuteron and a triton are far more likely to repel each other while large distances separate them. Forcing a close approach requires high energy, which requires high temperature — as we shall see, temperature on the order of 10^8 °K. All this was well known to applied nuclear physicists in the late 1940s. The idea of building an "H-bomb" that fuses isotopes of hydrogen occurred to them, and also a way to attain the high temperature: explode a fission bomb in the middle of a hydrogen-isotope mixture. If the bomb is made large enough or is surrounded by heavy material, then inertia alone will keep it together for the microsecond or so that the reactions require.

Clearly that scheme will not do for controlled fusion in a power plant. Gravity will not work either, for only on the scale of the sun (or more precisely on about the scale of Jupiter) would it be strong enough to force the nuclei together. What is left? The reacting particles are fully ionized — they are nuclei with all the electrons stripped from them. Since they are charged, perhaps magnetic forces will confine them.

Thus arose the first epoch in controlled fusion research, starting in the early 1950s. In summary, it was characterized by four realizations. First came measurements of reaction energies and rates between hydrogen isotopes and other light elements, which showed that under proper conditions large energy releases would be possible. Second, the well-known laws of single-particle physics seemed to show how an assembly of high-energy ions and electrons could be confined in magnetic fields long enough to establish the proper conditions. Third, the radioactive ingredients and byproducts of fusion were known to be much less hazardous than those associated with nuclear fission: therefore fusion reactors would be simpler and safer than fission reactors. Fourth, deuterium was known to be in plentiful supply. Only the first of these realizations is a prerequisite for making H-bombs. The combination of all four captured the imagination of a sizeable and very competent fraction of the physics community. The ensuing search for controlled fusion — the ultimate energy source, the source that powers the stars — has sometimes taken on a moral character, possibly as a reaction to the darker uses to which nuclear energy has been put. Whatever the reason, the efforts exerted by some were like those lavished on Mt. Everest — and a good thing, too, for the 1953 workers had anticipated very few of the complexities in both science and technology that had yet to be overcome before controlled fusion could reach even the half-way stage where it is today. The whole field of plasma physics — the physics of ionized gases — had yet to be invented at that time; superconducting magnets — absolutely essential for most fusion concepts — were not even contemplated. A controlled fusion reactor seemed like a simple thing; but in fact it is not. Developing one, assuming that it can be developed, will be scientifically and technologically more difficult than developing a fission reactor in roughly the measure that a fission reactor is more difficult to develop than a coal-burning power plant.

The Design of a Fusion Reactor

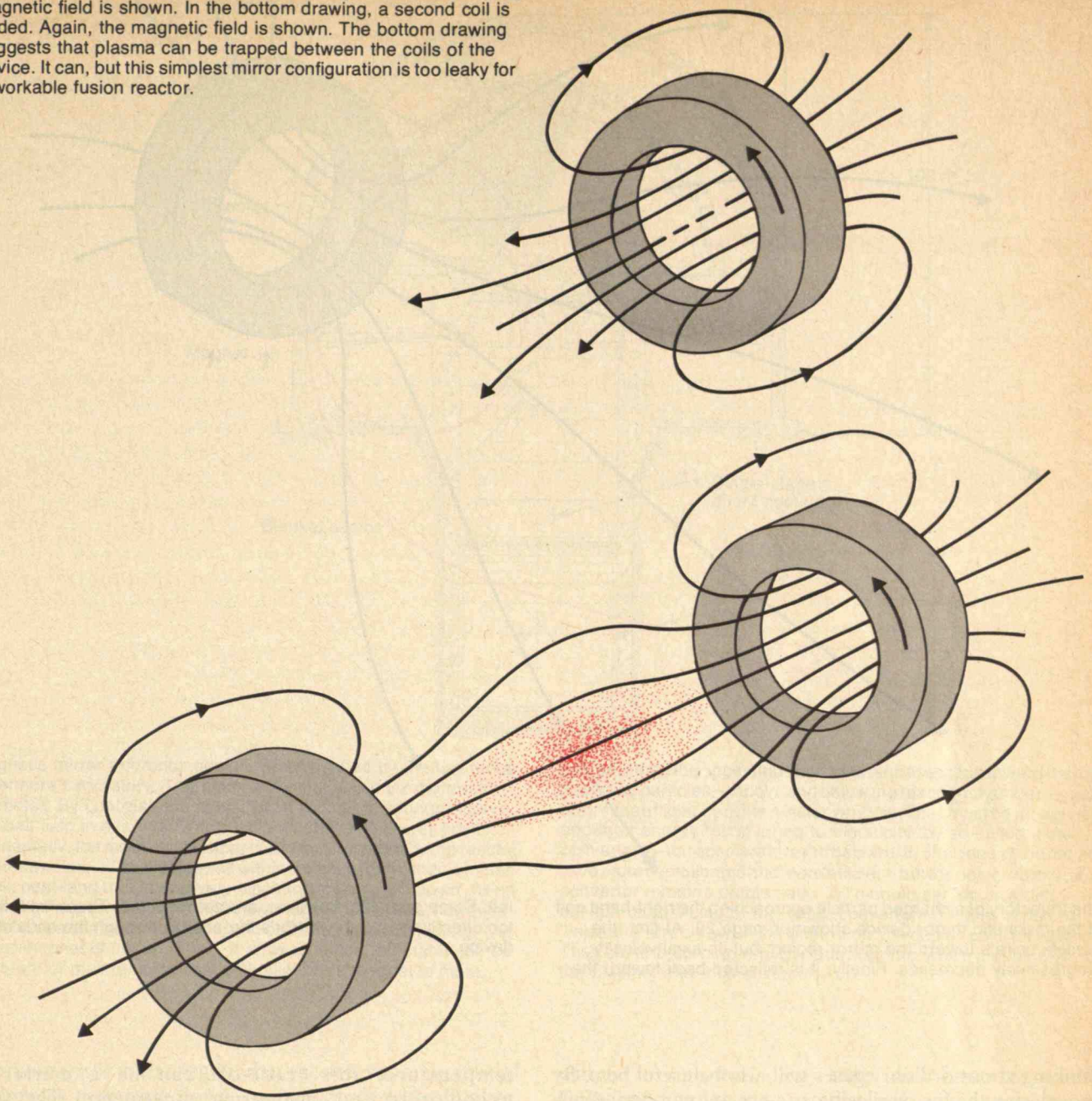
It is possible to describe many of the design requirements for a fusion reactor using only simple physical principles and a little common sense. Consider first a deuteron and a triton that are supposed to fuse, and consider also a "target area" associated with one of the particles. The other particle must pass within this area if the two particles are to interact — that is, combine, disintegrate, or even just scatter. The target area will have a different size for each different type of reaction; and for a fusion reaction it will grow larger if the incoming particle is more energetic — that is, if it has higher velocity — up to a limit that does not concern us here. The target area is called a reaction cross-section, and is measured in units of "barns," as in the familiar taunt, "You couldn't hit the broad side of a barn." One barn is 10^{-24} square centimeters.

The illustration on page 25 shows several fusion cross-sections for reactions among light nuclei. We see that no reactions involving protons as fuel have usefully large cross-sections. Not shown at all in the table is the two-proton reaction by which the sun is burning hydrogen. That reaction has a cross-section about 10^{-20} of the deuterium-tritium reaction; accordingly, as we noted, the sun takes billions of years to consume its hydrogen — a time suitable for stars, but not for the fusion reactors we have in mind.

Several lithium reactions are shown; they have smaller cross-sections than deuterium, tritium, or ^3He reactions because of the higher repulsive force between the particles. Thus lithium is good for breeding tritium but not for the fusion reaction itself, and we apparently must consider deuterium, tritium, or helium. In fact, the choice is more limited. It will turn out that producing more energy than is consumed will be a significant problem in fusion reactors: the constituents must be heated to the reaction temperature, and even then only a small fraction of the hot fuel will react in one pass through the reactor. Power will also be needed for other purposes. This energy-balance difficulty pertains even to the deuterium-tritium reaction, but noting that the deuterium-deuterium and deuterium-^3He reactions have cross-sections that are smaller by factors of 30 to 100, we conclude that deuterium-tritium is the fuel of obvious choice, despite the need for tritium breeding and the problems of radioactivity.

Thus, from the illustration, we wish to extract a typical energy and cross-section for deuterium-tritium fusion. While 150 kev (thousand electron volts) and five barns seem ideal, it turns out that the associated temperatures and pressures are too high for many fusion schemes. Let us consider lower energies, say 20-50 kev, so that the average cross-section for the reacting particles will be about one barn — a convenient number to use in our discussions. A gas at 20 kev has a temperature of about 2.3×10^8 °K, a value far surpassing any temperature ordinarily found on earth. It is exceedingly hot — about ten times the temperature of the sun's core. Will the reacting particles be neutral atoms or will they be ions at this temperature? The question is easily answered by comparing some orders of magnitude. The energy required to ionize a hydrogen atom — that is, to remove its sole electron — is 13.6 ev. The energy required to split the two-atom hydrogen molecule into individual atoms is even less. Thus an assembly of 20-kev molecules will decompose into ionized nuclei and free electrons. And at these very high

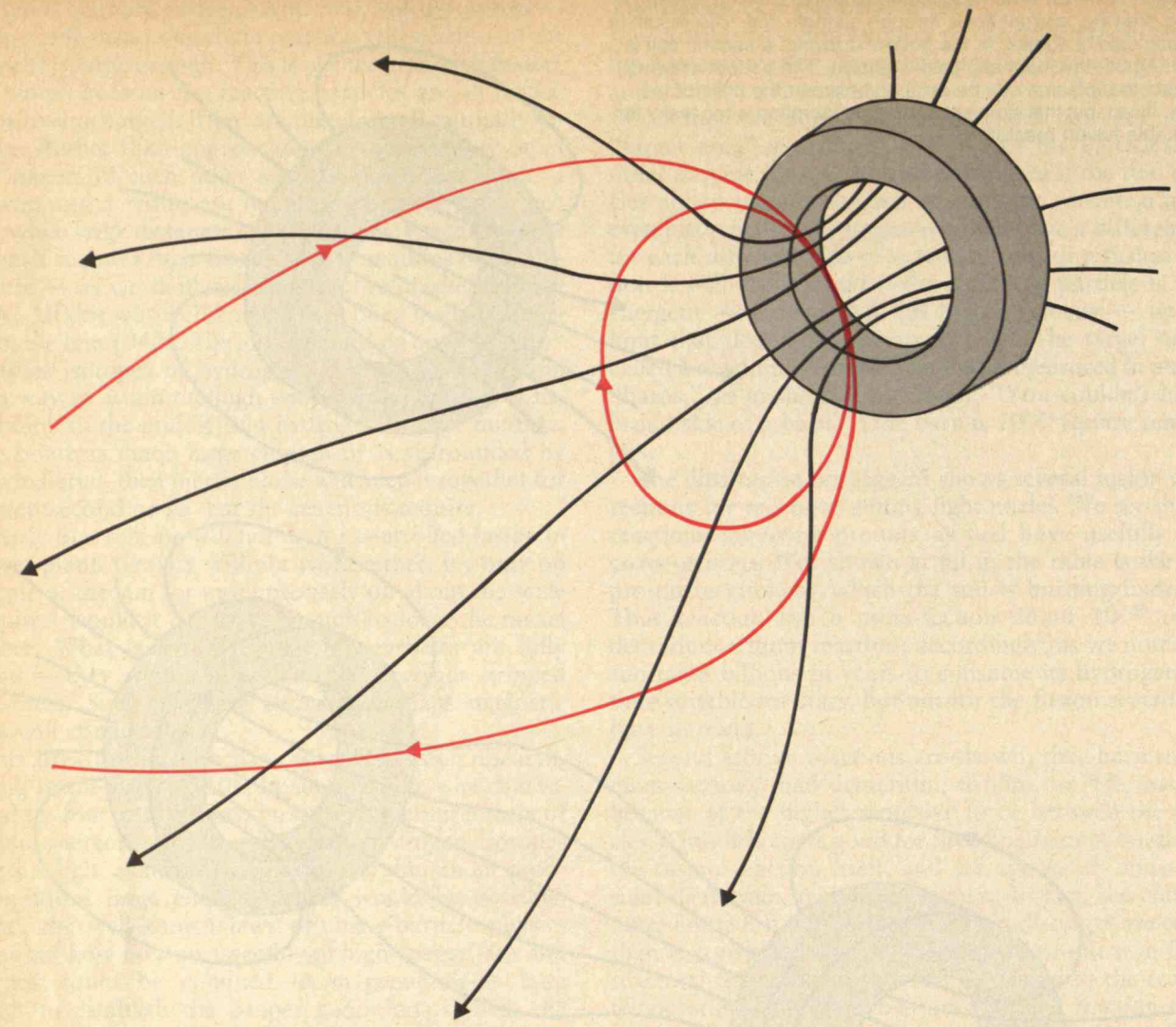
The magnetic mirror scheme for confinement of a fusion plasma. In the top drawing, current flows through a single coil. The resulting magnetic field is shown. In the bottom drawing, a second coil is added. Again, the magnetic field is shown. The bottom drawing suggests that plasma can be trapped between the coils of the device. It can, but this simplest mirror configuration is too leaky for a workable fusion reactor.



energies, the electrons will not recombine with the ions.

Moreover, these dissociation and ionization processes will occur rapidly. Cross-sections for reactions of this sort are typically about the size of the atoms themselves, say 10^{-20} square meters, which is 10^{8} times the fusion cross-section. Thus a collection of deuterium and tritium atoms at fusion temperatures will turn into a plasma containing, in this case, D^{+} and T^{+} ions, and an equal number of free electrons, in a time very short compared to the time the assemblage would require to undergo appreciable fusion. By this reasoning we can also conclude that a chance neutral atom injected into the fusion plasma will have a very short lifetime. This is not to say that a fusion plasma fully ionizes an arbitrary amount of neutral gas in the vicinity; the task requires energy, so the plasma cools, and too much addition of neutral gas will depress the temperature to uninterestingly low values. In addition, a truly fearsome atomic-type reaction called charge exchange can take place, wherein low-energy atoms (say at room temperature, with corresponding energy of about 0.03 ev) enter the plasma and exchange their charge with a high-energy (20 kev) ion; they become fast atoms that leave the plasma, perhaps to strike and damage the surrounding material walls.

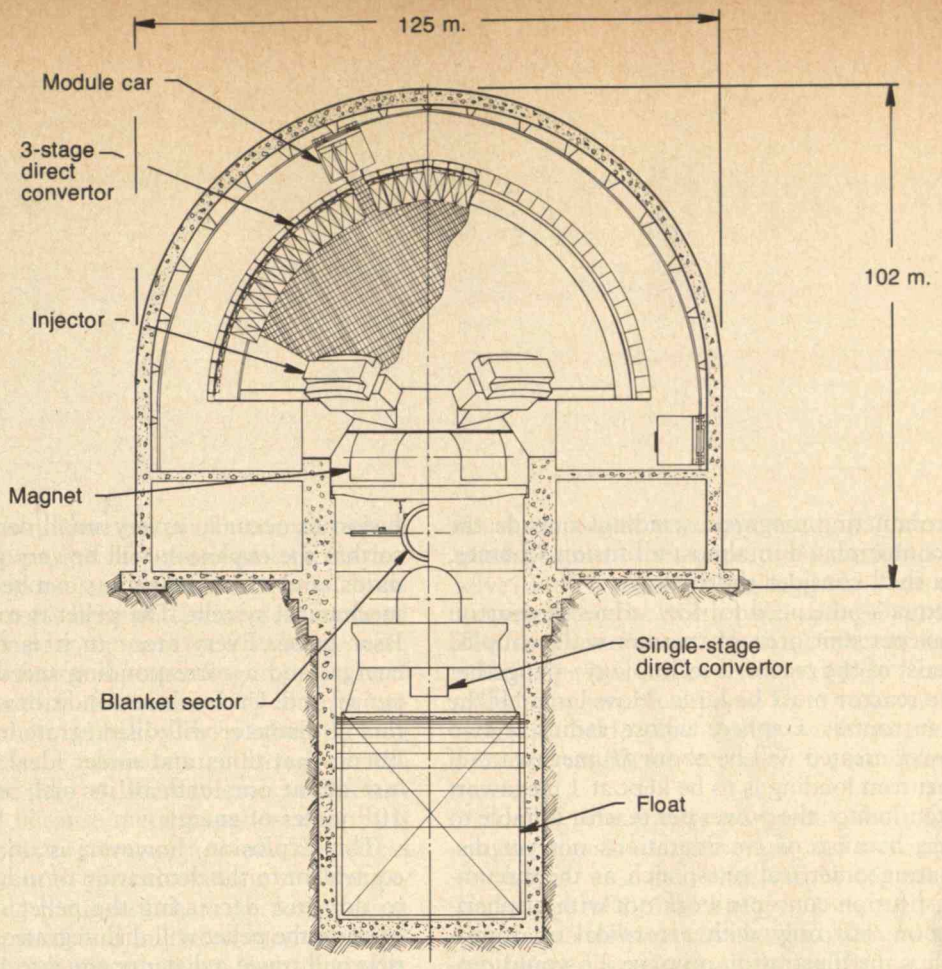
Another major question concerns scattering of the ions by each other before they come sufficiently close to fuse — a phenomenon we have mentioned briefly. For 20-kev ions, the scattering cross-section is about 2×10^{-26} square meters, which is 200 times larger than the fusion cross-section; and if the energy were less, scattering would dominate even more. The implication of this is that the assembly will become randomized: any given initial distribution, even of carefully focussed ion beams, will take on the properties of a gas after each ion has been scattered by its neighbors a few times. Accordingly, temperature, pressure, density, and other concepts useful in



The trajectory of a charged particle approaching the right-hand coil of the magnetic mirror device shown on page 29. At first, the particle spirals toward the mirror region, but its axial velocity progressively decreases. Finally, it is reflected back toward the left. Some particles, however, are not reflected. Those travelling too directly toward the mirror's throat pass through the ends of the device.

thinking about ordinary gases will also be useful here. By considering the fusion plasma as a gas, we can derive various combinations of temperature, density, and confinement time that are required if a substantial fraction of the fuel is to undergo fusion. One combination, assuming a plasma temperature of about 10^8 degrees Kelvin, is a density of about 10^{14} particles per cubic centimeter and a confinement time of about one second. That density is rather low (by comparison, the density of the air around us is about 3×10^{19} particles per cubic centimeter), so the plasma approximates a good vacuum. But the product of density and temperature is a measure of a gas's pressure, and in this example, the plasma's pressure turns out to be ten atmospheres. That is not fortuitous. Though large structures can be built to withstand pressures one order of magnitude greater, the extra order of magnitude must be saved to withstand the stresses that arise from high magnetic fields, soon to be described. For now, we note that as far as the physics is concerned, it doesn't matter whether one achieves high density and short confinement time, or low density and long confinement time, at a given temperature; this trade-off can be a matter of technological and engineering convenience. The fractional burnup of nuclear fuel will be the same.

We have discovered so far that the reactor contains a deuterium-tritium gas, confined in some way yet to be determined, for some period of time, inside an evacuated chamber — the vacuum being necessary in order to keep the plasma hot and pure. Thus we will need a vacuum wall. Now recall that 3.5 Mev, or a fifth of the energy created by deuterium-tritium fusion, appears in the velocity of the helium ion created in the reactions; and 14.1 Mev, or four-fifths, appears in the velocity of a neutron. We can imagine the charged particles being slowed down within the reacting plasma itself by electrical forces. On the other hand, the neutrons will not be affected by electromagnetic fields, nor will they be stopped by collisions within any reasonable length of the tenuous gas. They must pass through the vacuum wall into a surrounding "blanket" region of some sort, in which their velocity will be slowed and their energy converted into extractable heat. That was the reason for building the reactor.



Magnetic mirror reference design, as envisaged by the Lawrence Livermore Laboratory. The plasma itself is about six meters in diameter. By contrast, the power plant around it is longer than a football field in every dimension. (In most fission power plants, incidentally, the reaction chamber is similarly dwarfed by the reactor superstructure.) The plasma lies within a blanket more than a meter thick; heat- and tritium-recovery mechanisms are not shown. As on page 29, the plasma is confined by two magnet coils. Here, however, both have a complicated shape, and both are superconducting. The lower magnet is underground. It rests on a float so that it can be lowered for maintenance of the blanket. This magnet is more powerful than the upper; thus particles tend to escape toward the top. Escaping particles — above and below the reaction chamber — make the innate efficiency of the reactor very low. They must be recaptured, and their energy reconverted to electricity, by so-called direct convertors—ion accelerators run backward. The ones at the top are to be more complicated and more efficient, but the design of any direct convertor remains problematic. A "module car" is provided in the design for servicing of the upper convertors. Finally, a pair of "injectors" are shown in the illustration; the design calls for several. They are to inject high-energy neutral atoms, which are reionized by the plasma, and thus sustain it.

Moreover, it is in this region that the neutrons must breed tritium as they slow down and are captured in lithium. Our rudimentary fusion reactor now starts to take shape; it is shown in the illustration on page 27. The major missing component is a mechanism for plasma confinement, to be discussed shortly.

How thick must the blanket region be? Assume it is made of solid or liquid moderators, absorbers, and so on, all of whose density is typically about 5×10^{28} particles per cubic meter. The cross-section for a 14-Mev neutron colliding with a nucleus inside such materials is about 2×10^{-28} square meters, or two barns, and the corresponding mean penetration distance before the first collision is about 0.1 meters. But the blanket must be much thicker than that in order to stop all but a negligible fraction of the fast neutrons, and moderate the neutrons in energy so that they can be absorbed in lithium. Calculations show that the blanket must be about ten times as thick, or about one meter; and even then further shielding may be required outside.

Almost intuitively, we foresee that the fusion blanket will be a high-technology item, and hence expensive. Compounding this cost problem will be the vacuum wall itself, called in the trade the "first wall." Every 14-Mev neutron must pass through it on its way to the Retirement Village where it regenerates tritium — a circumstance in sharp and important contrast to that in fission reactors, where most of the energy appears with fission fragments, which are stopped in the fuel itself. It takes no great insight to see that material damage via irradiation by 14-Mev neutrons will be one of the most severe problems that fusion reactor designers must face. In the first place, some of the neutrons, and all of the x-rays and other radiation from the plasma, will give up energy at the vacuum wall. Calculations of permissible heat transfer show that the total energy incident cannot be allowed to average much more than a few megawatts per square meter, and possibly must be less. In the second place, one wishes to limit the number of neutrons penetrating all the way through the blanket, so as to minimize damage to outside apparatus, which will doubtless be expensive. (This requirement will certainly be true if we consider putting ex-

pensive superconducting magnetic windings outside the blanket, as is contemplated in almost all fusion schemes, for reasons we shall consider shortly.)

All these factors — the need for low values of neutron and energy flux per unit area of vacuum wall, coupled with the high cost of the reactor's technology — together dictate that the reactor must be large. How large? If the vacuum wall surrounds a sphere whose radius is two meters, the power created will be about 50 megawatts if the first-wall neutron loading is to be kept at 1 megawatt per square meter. In fact, the power per reactor is liable to be much larger, because of considerations not yet discussed. Some are geometrical ones, such as the circumstance that most fusion concepts work not with a spherical plasma region, but only with a toroidal or donut-shaped one. Thus the illustration on page 27 would represent a cut through a torus. If the minor radius to the vacuum wall will be two meters, the major radius will be five meters or more, the total vacuum-wall area will be 400 square meters or more, and the reactor power will be comparable with that produced by large present-day power plants.

Schemes for Plasma Confinement: Laser Fusion

At last we consider how to confine the plasma. The only physical confinement principles that exist are:

— Gravity, which won't work on earth. It can work on the sun due only to that body's mass.

— Material walls, which are self-defeating: it isn't that the plasma would melt the walls, but more likely the plasma's ions and electrons would lose their energy and cool on their first encounter with their container.

— A surrounding colder gas, which is not proven to be entirely unfeasible, but suffers from several problems, among them the energy-loss syndrome of material walls.

— Static electric fields, which are impossible, not only because oppositely-charged particles — nuclei and electrons — must both be confined, but also because the fields required to confine either species would be huge.

— High-frequency electromagnetic fields, which have been seriously studied; but the prognosis is poor, partly because of the undesirable electrically-driven particle motions, and partly because the power required for the scheme is very great.

Two principles remain: inertia and magnetic fields. We turn first to the simplest idea of all — inertia, as in the H-bomb itself. Here, nothing confines the plasma; it is heated to a sufficient temperature so rapidly that it fuses before the particles can go anywhere. The idea is to cause fusion to occur in a very small deuterium-tritium pellet, so that the explosion will be very small by nuclear standards, and its consequences can be managed by a simple mechanical system. The pellet is to be heated by a giant laser pulse. Every atom in it is to reach (say) 10-kev energy, and a corresponding speed of about 10^6 meters per second. Under these conditions, a pellet two centimeters in diameter will disintegrate in about 10^{-8} seconds. But in that time, and under ideal circumstances, it will fuse about one-tenth of its fuel, and release more than 10^{11} joules of energy.

This explosion, however, is unacceptably large: it is equivalent to the detonation of many tons of TNT. What to do? Just decreasing the pellet diameter won't work, because the pellet will disintegrate quicker (i.e., each particle will travel a distance equal to the pellet's diameter in a shorter time), and a too-small fraction of the fuel will undergo fusion. In principle, there is a way out, based on the fact that the fusion reaction rate increases as the square of the pellet's density. This is the key: smaller pellets will work if compressed by the laser pulse itself. The pulse is to be very short and very intense; it is to evaporate the outer layers of the pellet so rapidly that the momentum change of the material leaving the surface creates a compressive force in the remaining core. The pellet's density will then rise well above that of the original solid, and fusion can now occur with a smaller total amount of fuel. Thousand-fold compression of the pellet is planned, not only to ensure that the pellet burns well, but also to heat it to the initial fusion temperature. At high density (4×10^{31} particles per cubic meter), the pellet will undergo fusion in about 10^{-11} seconds.

We now have a fair picture of laser fusion. We imagine a mighty laser, with many beams impinging on the pellet to insure even illumination, and thus ensure that the pellet will compress. If the illumination were uneven, part of the plasma would spurt out where the intensity of the impinging light is even slightly lower.

Why won't this work? We see at least three reasons. First, the laser necessary to implode the pellet must produce a million-joule pencil of light in a pulse lasting a billionth of a second; and it must do so with high efficiency, or else it will consume more energy than the fusion reactor can generate. Such a laser does not now exist, and its science remains very unclear. While there have been remarkable advances in lasers, they have come mainly by extension of well-known science. Even then, they have come at very high cost.

Second, laser fusion necessarily implies a pulsed reac-

tor, one that produces nuclear heat in bursts perhaps a fraction of a second apart, but the unfortunate fact is that pulsed reactors must operate under far less internal stress than steady-state reactors, because cyclic stress tends to fatigue materials. Consider the reactor's vacuum wall, and suppose that laser fusion is proceeding in pulses next to it. The vacuum wall is first heated by the fusion-released energy, and then cooled by the coolant flowing behind the wall. Thus the temperature throughout the wall cyclically rises and falls to different levels at different depths within it; and because metal expands when it is heated, the result is a cyclic stress in the wall. That stress is well calculable, and both the calculations and the experiments made to date suggest that the laser-fusion schemes thus far proposed will fail from thermal stress alone, unless the walls are placed so far from the pellet that the thermal stress becomes negligible. But in that case, the device becomes too huge and too expensive for the small amount of energy that can be captured — a circumstance that will not please the stockholders.

The third problem may be the worst. Imagine that the fuel starts out as a one-millimeter pellet, and that the laser light shining upon it creates an inward force on its surface that compresses the pellet by a factor of a thousand, to a final diameter of a hundred microns. Throughout this compression, all the light of the million-joule laser must remain focussed upon it. Now the light must come from large optical surfaces — mirrors, probably — of most remarkable quality, most carefully placed, for no ordinary searchlight mirror will focus all its energy down on a hundred-micron spot. There will be perhaps ten or twenty such mirrors, each a meter in diameter, surrounding the little pellet, which compresses and undergoes fusion in 10^{-11} seconds, and releases about 10^{8} joules — the energy content of a satchel full of dynamite. Alas, that amount of nuclear heat is worth about five cents, even at today's inflated prices, and so the explosion must cause very much less than five cents' worth of damage and disalignment to the optical surfaces, considering all the other costs of building and operating the reactor.

Schemes for Plasma Confinement: Magnetic Mirrors

Evidently the little pellets that can be fried so cavalierly in computer simulations cannot so easily be fried in a fusion reactor. The final possibility is magnetic confinement of a plasma. We therefore turn to an examination of magnetic forces.

Most people have seen iron filings sprinkled on a sheet of paper with a bar magnet placed underneath; it is a ritual of adolescence practised in high school science classes. A tap of the paper, and the filings arrange themselves into a pattern that suggests a set of curved lines looping from the north pole of the magnet to the south. The lines bunch most closely near the poles, and are most widely spaced far from the magnet. These are the so-called magnetic field lines. They are a way to represent a magnetic field, which otherwise is an ethereal thing. Its presence cannot be seen until the iron filings line up and reveal it.

For us, the feature of paramount importance about magnetism is that in a straight and uniform magnetic field — that is, in a field that can be represented by evenly spaced, parallel field lines — a charged particle is constrained to follow a circular path around a field line. If an arbitrary constant velocity along the magnetic field is also imparted to the particle, then its trajectory will be a corkscrew with its axis along a field line. In short, the charged particle's trajectory will be tied to the line. Moreover, if the line is slightly curved, the particle will *almost* remain tied. (The importance of the qualification "almost" will appear later, when we describe tokamaks.)

The particle's bondage suggests a scheme for plasma confinement that is most easily understood if we build it up in two stages. The top drawing on page 29 shows a single magnet coil carrying a current. The resulting magnetic field lines are also shown, and we have no trouble in seeing that the field is strongest in the plane of the coil, where the field lines bunch together, and progressively weaker at increasing distance from the coil, even on or near the axis. Now imagine two such coils, as in the second drawing. Each carries a current in the same direction. If the coils are suitably far apart, some of the diverging field lines from one coil will be "caught" by the other and will pass through it; accordingly the field's strength will be greatest in the throat of each coil, and less in the space between.

This is a simple magnetic mirror. The name describes a changed particle's motion in the field that the two coils create. Consider the figure on page 30, which is an abstracted and idealized view of the field lines as they approach and pass through the right-hand coil. Imagine that a positive ion is gyrating about the axial field line and that it has some velocity toward the right-hand coil. Now the magnetic force on the ion is always perpendicular to the field line and to the particle's orbit. Therefore it points toward the axis; this is what makes the particle gyrate around it. But because the field lines converge — because they are not parallel and evenly spaced — a component of

the magnetic force also pushes the ion away from the high-field region. Accordingly, the ion's progress toward the coil is slowed, but because the magnetic field is unchanging, the ion's total energy remains constant — its loss in axial energy is offset by an increase in rotational energy. In the illustration, the ion spirals toward the coil until it loses all its axial velocity, and then it spirals back. When it reaches the other magnet coil, it will be reflected there as well. Thus it will remain inside the magnetic cage more or less indefinitely, unless some other phenomenon intervenes. Seemingly we need only heat up a fusion plasma and maintain it between two magnetic mirrors, and we will have a fusion reactor.

How shall the plasma be heated? Present ideas call for large particle accelerators to produce ion currents totalling thousands of amperes at a voltage of (say) 100 kev. The ions, as such, would not be able to cross the magnetic field and enter the confinement region; therefore they must be reconverted to neutral atoms before injection. Once inside, the plasma already present will re-ionize them and they will promptly become trapped on magnetic field lines. In sum, the injection process, as now envisaged, proceeds from neutral gas in a storage tank, to energetic ions emerging from the accelerator, to energetic neutral particles at the entrance to the fusion chamber, and finally to energetic ions within the fusion plasma — surely a very roundabout method. Yet it has been tried with good success on moderate scales, producing, for example, beams of 20 amperes at 50-kev energy.

Do we now have a workable fusion reactor? Not yet. Notice that the magnetic field, in its confining effect on charged particles, acts as if it exerted a pressure: where the field strength is high, the pressure pushing against charged particles is high. On axis in a magnetic-mirror device, the field strength — and thus the pressure — reach a relative minimum between the two coils, just as one would hope, seeing that a high-energy plasma is to be confined there long enough for it to undergo fusion. But unfortunately the field strength also falls off as one moves radially outward, away from the axis. This means that the plasma is unstable: if too much gas is injected between the mirrors, the plasma will develop an aneurism and pop, like a bicycle tire with too much air pumped into it. The problem can be cured by causing the magnetic field to have a true minimum in the middle of the device. But there is a cost: the magnetic field and the coils that produce it become very complicated. In some designs, the coil windings come to look like the seams on a baseball.

Having modified the design, do we *now* have a fusion reactor? Still no, for a second problem remains, and it is far more serious: If an ion between the mirror regions happens to be travelling straight along a magnetic field line, or nearly in such a direction, the axial decelerating force acting upon it will be weak. Thus, ions with velocities directed more or less axially will not be reflected. Instead, they will pass through the high-field region, and escape from the ends of the device. We sorrowfully conclude that the magnetic mirror is leaky. But how leaky? The calculations show that each scattering of an ion is fairly likely to send it flying out the end of the magnetic mirror. This means that the ion is unlikely to stay in the device long enough to undergo fusion because, as we found earlier, even a 20-kev ion is likely to scatter many times before it fuses. For this reason, it appears that the energy released by fusion in a magnetic mirror will be approximately equal to the energy that was required to heat the plasma to fusion temperature in the first place. Now the released energy must be converted, at some loss, from heat to electricity. Moreover, energy is required to maintain the steady-state magnetic field that confines the plasma, however poorly, between the mirror regions. In sum, the device seems to be an energy-loser, not an energy-maker.

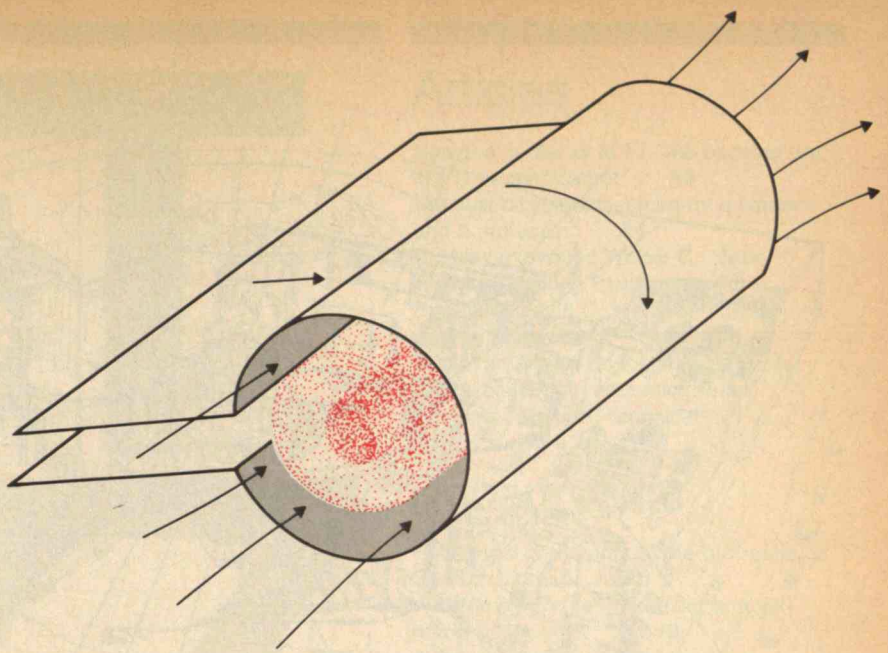
Immense efforts are now underway to solve the energy-balance problem by developing a way to recover energy from the plasma not only in the form of heat but also directly, as electric power. The idea is to have particles that scatter out the end of the reaction chamber pass immediately into a so-called direct converter — in essence, an ion accelerator run backward. Here the ions are made to decelerate. Their kinetic energy, lost in this way, reappears in an external electric circuit as delivered power. Valiant attempts also proceed to ameliorate the basic problem — the confinement quality of the magnetic mirror itself — by placing subsidiary mirrors at each end, by injecting ions in artful ways, and so on. Whether these various projects will succeed is still unclear. Yet the magnetic-mirror scheme will require success in at least some of them if its energy balance is to be made attractive.

We may be cruel to end this account of magnetic mirrors by noting that nature successfully deploys enormous mirrors above our heads. High-energy ions are produced in space by solar flares or by cosmic rays. They may be trapped by the earth's magnetic field, which looks much like the field of a bar magnet. If trapped, they follow corkscrew trajectories around a field line until they near the north or south magnetic pole, and there, where the field lines close in and the field strength rises, they are reflected. The space around earth is thus occupied by charged particles shuttling back and forth between mirrors at the polar regions. The heavenly mirrors, however, are no fusion devices. Indeed, they are no better at confining a plasma than their earthly namesakes. Particles almost continuously escape and rain down into the upper atmosphere, where they create the aurora borealis in the northern hemisphere, the aurora australus in the south. When solar flares modulate the solar wind, and rattle the configuration of magnetic field lines far out in space, the aurorae become more spectacular.

Schemes for Plasma Confinement: Theta-Pinches

A second fusion device employing magnetic plasma confinement is shown in schematic diagram at the right. Its principle of operation seems to be fairly simple: Electric current is made to flow around a cylinder. In doing so, it creates a magnetic field whose field lines (within the cylinder, at least), are parallel to the cylinder's axis. If cold, dilute plasma initially lies within the cylinder, an immediate increase in the magnetic field strength will compress the plasma into a rodlike region at the cylinder's axis; and if this increase is sufficiently rapid, the compression can also shock-heat the plasma — sufficiently, perhaps, so that it will start to undergo fusion. The device is called a theta-pinch because the direction in which current flows around the cylinder, by world-wide convention among fusion researchers, is labelled by the Greek letter theta.

Compressing and heating a plasma requires energy. Doing it quickly requires that the energy come quickly — in other words, that the power be high. Accordingly, theta-pinches will require enormous power supplies, of



The theta-pinch scheme for plasma confinement. Current is made to flow abruptly around a cylindrical surface. This induces a magnetic field that compresses and heats a deuterium-tritium mixture contained within the cylinder. For reasons given in the text, two power supplies and associated switching mechanisms are required, and the larger supply, used for plasma compression, must be superconducting, or the reactor will lose energy, not make it. The power supply's design remains to be invented. One major fault of this schematic drawing: if the cylinder in a real theta-pinch reactor were straight, it would have to be several kilometers long, or plasma being compressed would spurt out its ends before fusion could occur. Actual designs call for the cylinder to be bent so that its ends meet, obviating the problem. But other problems persist.

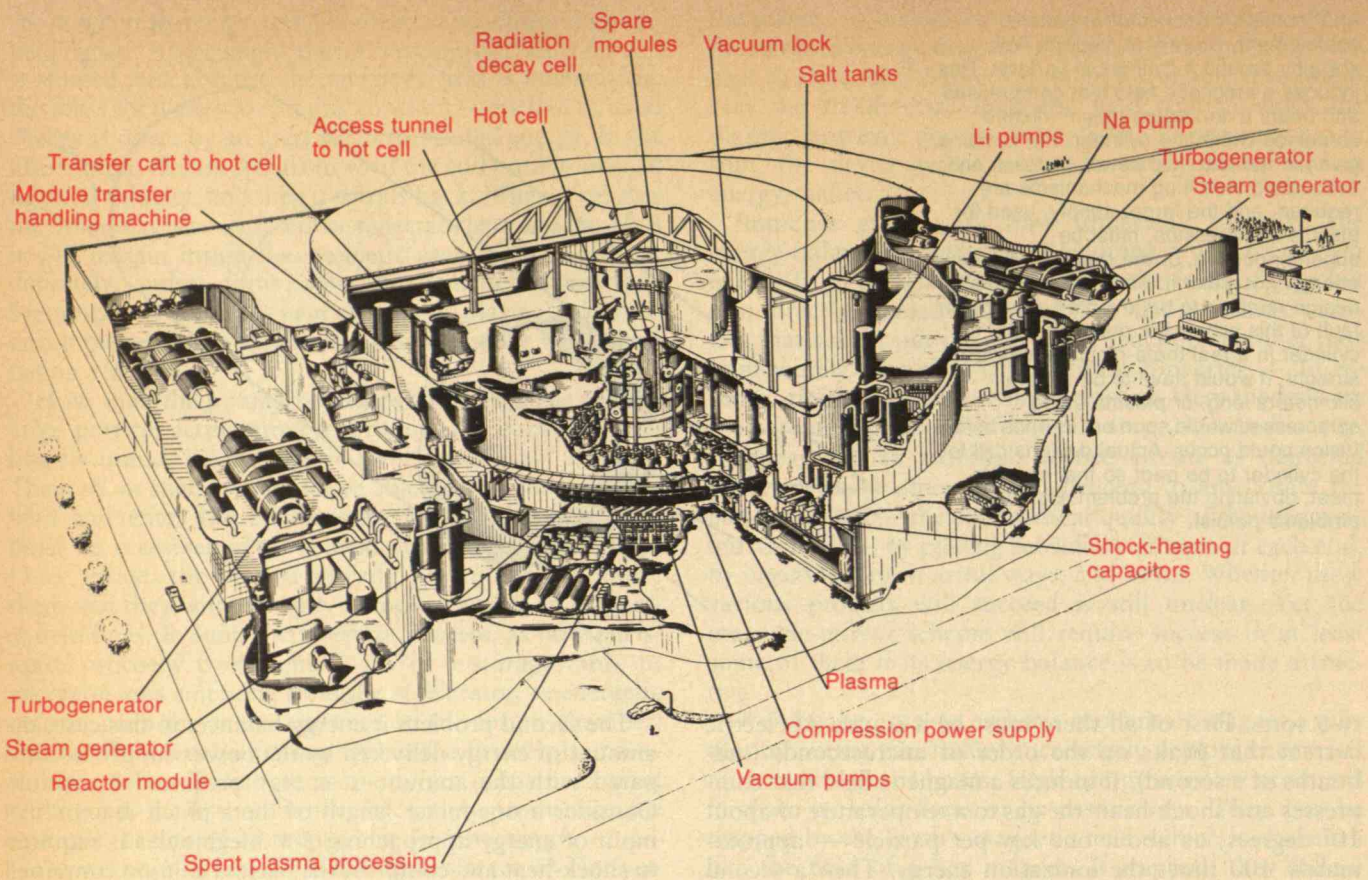
two sorts. First of all there must be a source of electric current that peaks on the order of microseconds (millionths of a second). It induces a magnetic field that compresses and shock-heats the gas to a temperature of about 10^7 degrees, or about one kev per particle — approximately 100 times the ionization energy. Then a second power supply, cut in by suitable switching, takes over. It further heats and compresses the plasma, this time on the order of milliseconds (thousandths of a second). Presumably fusion now occurs. Two stages of heating and compression are necessary because of the differing time scales. To supply energy on the order of microseconds, capacitors must be used, and capacitors are expensive. To supply energy on the order of milliseconds, cheaper equipment will work. It could be managed, for example, by rotating machinery — so called homopolar generators, which contain elements that spin at a high rate of speed. When they are slowed, an appreciable fraction of their rotational energy is converted to electrical energy.

Why won't *this* confinement scheme, which worked so well at the plasma-physics stage, work for a commercially interesting reactor? The first problem is that the theta-pinch, like laser fusion, requires a pulsed reactor, with a consequent cycle of thermal stress. Each spurt of fusion in a theta-pinch reactor will last 10^{-2} seconds, not 10^{-9}, but failure of the vacuum wall through cyclic overstressing will still be a problem. Experiments suggest that only 10^5 to 10^6 cycles can be withstood by a vacuum wall, and thus, with one pulse occurring per second, as the proponents of the theta-pinch hope, the reactor will have an operating life lasting well under two weeks. Dismal as this sounds, the true stress problem may be even worse, for in the theta-pinch reactor, the metallic cylinder through which current flows will experience a force that arises because the current sheet lies within the very magnetic field that it creates. This is the familiar force that turns electrical machinery. Here, in the cylindrical geometry of a theta-pinch reactor, it will be equivalent to a pressure coming from within. Because the current comes in pulses, so does the pressure, and the cyclic stress problem is exacerbated.

The second problem is energy balance: in this case, the amount of energy delivered by the power supply as compared with the amount of energy produced by fusion. Consider a one-meter length of theta-pinch reactor. An input of energy approaching 200 megajoules is required to shock-heat and compress the plasma column contained therein; an output of fusion-released heat approaching 6 megajoules is the result. The reactor, then, is a sure loser, unless the power supply's energy can be recyled with incredible efficiency. But doing so will require superconducting pulsed magnets, and superconducting switches as well. The former are currently being made in small sizes; however, the design for larger versions remains hard to foresee. The latter will be harder still to develop. The need for these devices suggests that the cost of a theta-pinch will be frightening, if only because the cost of a system often relates fairly closely to the amount of energy that it must handle.

Problem number three: Suppose that all the other problems have been solved. The fusion reaction proceeds. At the end of each pulse cycle, the magnetic field must drop, in preparation for the succeeding cycle. In consequence, the remaining plasma re-expands to fill the original cylinder volume. Even if fusion no longer proceeds within it, that plasma is still close to fusion temperature. It is a peril to any material surface that it hits, and on the time scale of operation envisaged for a theta-pinch reactor — a fraction of a second per cycle — no way is known by which to protect the vacuum wall from its onslaught. To keep the plasma from hitting the wall, the magnetic field lines would have to suddenly change their configuration at the end of each cycle in such a way that gas nearing the wall would be guided into some receiving area where it could be cooled. The alteration of the magnetic field must be interfaced with the rest of the cycle, and moreover it must not interfere with the onset of the succeeding cycle. Considering the device's rapid pulsing, its awful energy balance, its precarious technology, and its cost, that feat seems impossible.

One non-magnetic scheme to save the vacuum wall of a theta-pinch reactor has been explored. The hope was to have thousands of little pipes perforating the vacuum



Theta-pinch reference design proposed by Los Alamos Scientific Laboratory and Argonne National Laboratory. It suffers from several problems, as described in the text. The reaction chamber is a ring of modules, each working on the principle schematized on page 35. It is thought that each can be removed for servicing, first to a "radiation decay cell" where, in perhaps a day, it will lose much of its radioactivity, and thence to a "hot cell," where maintenance and repair is to be conducted. Power supplies occupy much of the remaining space around the reaction chamber. Even so, their size may have been underestimated. The reactor is cooled by a series of systems interconnected by heat exchangers. Lithium and lithium salts remove heat from the reactor. Their heat is removed by sodium, which then surrenders it to steam in an exchanger much like the one proposed for the liquid metal fast breeder reactor. Finally, the steam generates electricity in turbogenerators at either side of the mammoth building.

wall. At the end of each cycle, puffs of gas would enter the reaction chamber by way of these pipes, and a cooling gas blanket would be created around the plasma. The idea cannot work, because the cooling gas obeys the kinetic theory of gases, according to which some atoms in that gas will have higher velocities than others; and they will reach the plasma first. Here many of them will exchange their charge with ions in the plasma, in the fearsome type of reaction we noted much earlier in this article, and become marauding atoms. Thus, one way or another, high-energy particles will smash into the vacuum wall before the slower particles can enter and erect a gaseous shield.

Schemes for Plasma Confinement: Tokamaks

In searching for another magnetic scheme by which to confine a plasma, we begin again with the basic configuration of a theta-pinch: a long, straight cylinder with current circling through it. Assume that the current travels through windings coiled around the cylinder, as in a solenoid — a helix of electrical conductor. Now the cylinder can be gently bent until it has a circular shape. The cylinder becomes a torus, a doughnut. Not only do its ends meet, but so do the ends of the field lines within: they are closed loops now.

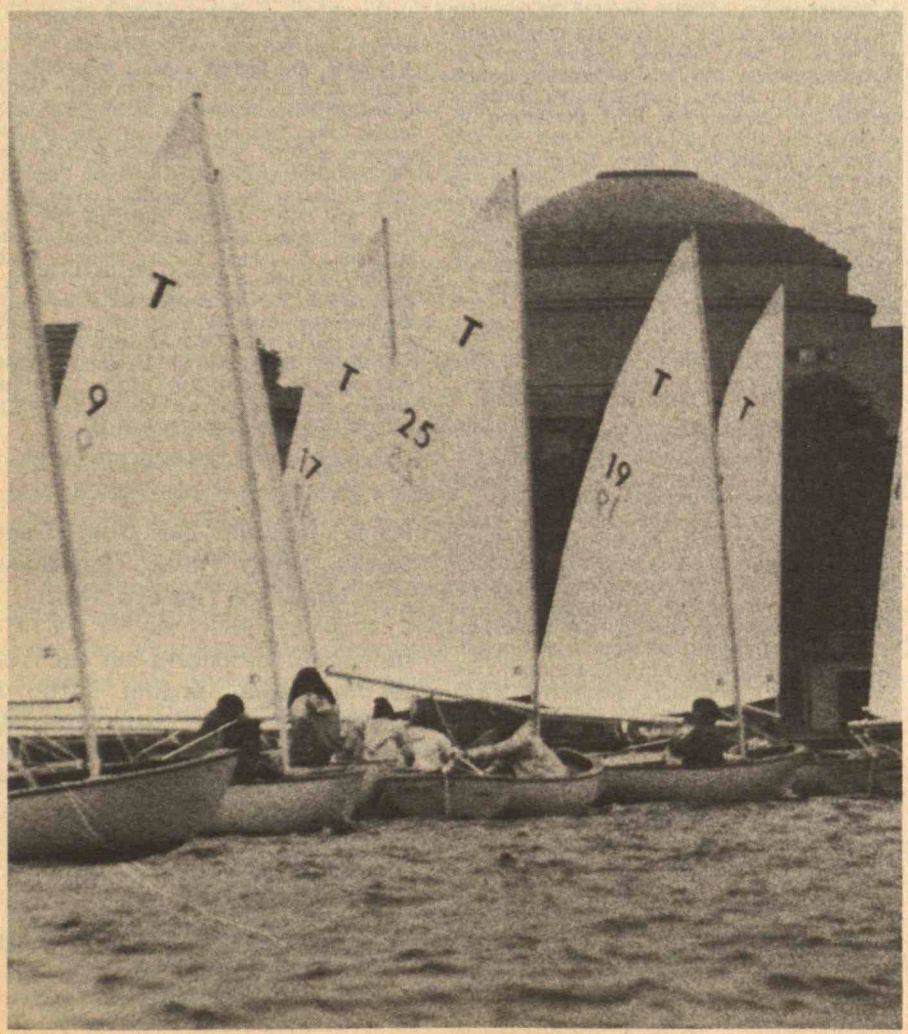
It might be imagined that the confinement problem is solved — just pump in plasma, and at suitably impressive magnetic field strength it will remain confined at high temperature and density long enough for fusion to occur. In reality, there are difficulties. The principal one is that the plasma ions cannot be kept from drifting to the sides of the torus, because curved field lines in fact yield not the perfect gyration circles we have considered thus far, but almost-circles that gradually drift across the magnetic field. These drifts cause ions and electrons to be lost in opposite directions, since they are oppositely charged; and the separation of positive and negative charges by means of these drifts gives rise to *electric* fields, which cause profound plasma motions. The result is impact of the plasma on the confining vacuum walls in times that are short compared to the desired confinement time. The heart of the trouble, expressed in another way, is that a plasma inside the torus experiences a larger magnetic pressure on its inner periphery than on its outer periphery. Thus it is basically unstable against motion radially outward — motion toward the outer torus wall.

Fortunately, this ill seems curable. The illustration at the right shows the torus in perspective. The windings that wrap around the cylinder are present as before: they induce the magnetic field whose field lines run lengthwise through the doughnut. But note that the primary coil of a transformer has been added to the device. The secondary coil is the plasma itself. Now a pulse of current sent through the primary coil of any transformer induces a

MIT '77

Articles

Departments



A Note about MIT 77

MIT 77 is a regular feature of *Technology Review,* M.I.T.'s eight-times-a-year magazine reporting new developments at the Institute, in technology, and among alumni. This month we send MIT 77 to those alumni who do not receive *Technology Review;* we hope to better inform you about M.I.T., to kindle your interest in the Institute, and to stimulate you to participate in its alumni activities.

If you'd like a sample copy of the *Review,* please write me your request. And be sure that we'll always welcome your comments.

James A. Champy, '63
Executive Vice President
M.I.T. Alumni Association
Room 7-204, M.I.T.
Cambridge, Mass., 02139

SPECIAL REDUCED ALUMNI RATES

TWELFTH ANNUAL TOUR PROGRAM—1976

1976 marks the twelfth year of operation for this unique program of tours, which visits some of the world's most fascinating areas and which is offered only to alumni of Harvard, Yale, Princeton, M.I.T., Cornell, Univ. of Pennsylvania, Columbia, Dartmouth, and certain other distinguished universities and to members of their families. The tours are designed to take advantage of special reduced fares offered by leading scheduled airlines, fares which are usually available only to groups or in conjunction with a qualified tour and which offer savings of as much as $500 over normal air fares. In addition, special rates have been obtained from hotels and sightseeing companies.

The tour program is consciously designed for persons who normally prefer to travel independently and covers areas where such persons will find it advantageous to travel with a group. The itineraries have been carefully constructed to combine as much as possible the freedom of individual travel with the convenience and savings of group travel. There is an avoidance of regimentation and an emphasis on leisure time, while a comprehensive program of sightseeing ensures a visit to all major points of interest. Each tour uses the best hotel available in every city, and hotel reservations are made as much as two years in advance in order to ensure the finest in accommodations. The hotels are listed by name in each tour brochure, together with a detailed day-by-day description of the tour itinerary.

The unusual nature and background of the participants, the nature of the tour planning, and the quality of the arrangements make this a unique tour program which stands apart from the standard commercial tour offered to the general public. Inquiries for further details are invited.

AEGEAN ADVENTURE

23 DAYS $2050

This original itinerary explores in depth the magnificent scenic, cultural and historic attractions of Greece, the Aegean and Asia Minor, including not only the major cities but also the less accessible sites of ancient cities, together with the beautiful islands of the Aegean Sea. Visiting Istanbul, Troy, Pergamum, Sardis, Ephesus and Izmir (Smyrna) in Turkey, Athens, Corinth, Mycenae, Epidauros, Nauplion, Olympia and Delphi on the mainland of Greece, and the islands of Crete, Rhodes, Mykonos, Patmos and Santorini in the Aegean. Total cost is $2050 from New York. Departures in April, May, July, August, September and October 1976. (Additional air fare for departures in July and August.)

SOUTH AMERICA

28 DAYS $2265

From the towering peaks of the Andes to the south Atlantic beaches of Rio de Janeiro, this tour travels more than ten thousand miles to explore the immense and fascinating continent of South America. Visiting Bogota, Quito, Lima, Cuzco, Machu Picchu, La Paz, Lake Titicaca, Buenos Aires, the Argentine Lake District at Bariloche, the Iguassu Falls, Sao Paulo, Brasilia, and Rio de Janeiro. Total cost is

$2265 from Miami, $2300 from New York, with special rates from other cities. Departures in January, February, March, April, May, July, September, October and November, 1976.

THE ORIENT

29 DAYS $2450

A magnificent tour which unfolds the splendor and fascination of the Far East at a comfortable and realistic pace. Visiting Tokyo, the Fuji-Hakone National Park, Kyoto, Nara, Nikko and Kamakura in Japan, as well as the glittering temples and palaces of Bangkok, the metropolis of Singapore, the fabled island of Bali, and the unforgettable beauty of Hong Kong. Optional visits to the ancient temples of Jogjakarta in Java and the art treasures in the Palace Museum of Taipei. Total cost is $2450 from California with special rates from other points. Departures in March, April, May, June, July, September, October and November, 1976 (extra air fare for departures July through October).

MOGHUL ADVENTURE

29 DAYS $2395

An unusual opportunity to view the magnificent attractions of India and the splendors of ancient Persia, together with the once-forbidden Kingdom of Nepal. Visiting Delhi, Kashmir (Bombay during January through March), Banaras, Khajuraho, Agra, Jaipur and Udaipur in India, the fascinating city of Kathmandu in Nepal, and Teheran, Isfahan and the palaces of Darius and Xerxes at Persepolis in Iran. Total cost is $2395 from New York. Departures in January, February, March, August, September, October and November, 1976.

THE SOUTH PACIFIC

29 DAYS $2895

An exceptional tour of Australia and New Zealand, from Maori villages, boiling geysers, ski plane flights and jet boat rides to sheep ranches, penguins, the real Australian "Outback," and the Great Barrier Reef. Visiting Auckland, the "Glowworm Grotto" at Waitomo, Rotorua, Mt. Cook, Queenstown, Te Anau, Milford Sound and Christchurch in New Zealand and Canberra, Melbourne, Alice Springs, Cairns and Sydney in Australia, with optional visits to Fiji and Tahiti. Total cost is $2895 from California. Departures in January, February, March, April, June, July, September, October and November 1976.

EAST AFRICA

23 DAYS $2165

The excitement of Africa's wildlife and the magnificence of the African landscape in an unforgettable luxury safari. Visiting Lake Naivasha, Lake Nakuru, Samburu Reserve, Treetops (Aberdare National Park), Masai-Mara Reserve, the Serengeti Plains, Ngorongoro Crater, Nairobi and Mombasa. Total cost is $2165 from New York. Optional visits are available to the Amboseli and Tsavo National Parks, the Victoria Falls, on the mighty Zambezi River between Zambia and Rhodesia, to Zanzibar, and to the historic attractions of Ethiopia. Departures in January, February, March, May, June, July, August, September, October, November and December 1976.

MEDITERRANEAN ODYSSEY

22 DAYS $1745

A unique and highly unusual tour offering a wealth of treasures in the region of the Mediterranean: Tunisia, with the ruins of Carthage and many other Roman cities as well as lovely beaches, historic Arab towns and desert oases; the beautiful Dalmatian Coast of Yugoslavia, with its fascinating and medieval cities; and the 17th and 18th century splendor of Malta. Visiting Tunis, Carthage, Dougga, Sousse, Monastir, El Djem, Gabes, Djerba, Tozeur, Sbeitla, Kairouan and Thuburbo Majus in Tunisia; Split, Trogir, Sarajevo and Dubrovnik on the Dalmatian Coast of Yugoslavia, and Valletta and Mdina in Malta. Total cost is $1745 from New York. Departures in March, April, May, June, July, September and October, 1976 (additional air fare for departures in June and July).

* * *

Rates include Jet Air, Deluxe Hotels, Most Meals, Sightseeing, Transfers, Tips and Taxes.

Individual brochures on each tour are available, setting forth the detailed itinerary, departure dates, hotels used, and other relevant information. Departure dates for 1977 are also available.

For Full Details Contact:

ALUMNI FLIGHTS ABROAD
White Plains Plaza
One North Broadway
White Plains, N.Y. 10601

Building 10 to be M.I.T. Alumni Center

The faith and vision of Ralph Huntington must have inspired William Barton Rogers' steps as he trudged the cold gray streets of Boston, seeking funds to establish his visionary institute of technology based on "the dignity of useful work." Mr. Huntington, a prominent Bostonian of the day, was an early benefactor, having made known in 1862 that his will contained a princely $50,000 legacy for M.I.T.

The new Institute's gratitude was permanently recorded when the large lecture hall in its Back Bay building was named in Mr. Huntington's honor. And when M.I.T. moved to Cambridge 50 years later the new lecture hall which similarly dominated its new main building was given the same name.

The seats were hard, the ideas often hard, too, the teaching occasionally brilliant, occasionally frustrating. But nearly every student — literally — who has ever studied at M.I.T. has memories of a Huntington Hall (now, sometimes, Room 10-250); its place is secure in the hearts of alumni (and of faculty, too, because it has been the scene of almost every faculty meeting in the Institute's 115 years).

Now that historic room — drab and spartan by present Institute standards — will be renovated under a $1.3 million program launched by the M.I.T. Alumni Fund. And Building 10, the centerpiece of the Institute's original Cambridge buildings, will become the locus for alumni activities at M.I.T. For the first time in M.I.T.'s recent history there will be a generous hospitality center, where visiting alumni will find a warm welcome as well as services and help to assure the success of their visits.

New plans for Building 10 were announced at the 1976 Alumni Officers Conference in September: Room 10-250 will be "brought into the 20th century," said Edward O. Vetter, '42, President of the Alumni Association. And on the first floor of Building 10, behind the formal entrance lobby and surrounding the Vannevar Bush Room, will be new headquarters offices for the Alumni Association.

Both are among the goals of M.I.T.'s $225 million Leadership Campaign, and their fulfillment has now been made a special project of the Alumni Fund. Mr. Vetter said the $1.3 million will be raised in three years, and President Jerome B. Wiesner — apparently confident that Mr. Vetter could fulfill his pledge — promised that work could begin early in 1977 with completion certain by the opening of the 1977-78 academic year. Architectural Resources of Cambridge has been chosen for the design work, which is already in progress.

The program for Huntington Hall laid out by the Institute's Planning Office includes improved acoustical treatment, lighting adequate for television productions in the lecture area, modern audio and projection facilities, air conditioning, new seats, and a new seating plan to eliminate the seats "shadowed" from the lecturn by structural columns.

The Alumni Association headquarters on the first floor of Building 10 will be arranged around an exhibition hall for displaying M.I.T.-related materials. The Vannevar Bush Room will become a meeting hall primarily for alumni events, and the outdoor courtyard behind will be incorporated as an entrance and social center. There will be offices for the President, Executive Vice President, and Secretary of the Association, the Regional Directors, the Director of the Alumni Fund, and their assistants. (The Alumni Records Office and *Technology Review* will be brought from the Ford Building to Building 12 — former home of the Chemical Engineering Department — nearby.)

It will be the first time in many years that offices of the Alumni Association have been assigned such a central place in M.I.T.'s buildings — a place commensurate with the role of the alumni in M.I.T.'s affairs, said Mr. Vetter. And the new Huntington Hall will represent another "permanent mark" of alumni on the future of the Institute.

How a Challenge Gift Can Turn $50 into $100

Remember when a mysterious "Mr. Smith," insisting on anonymity, responded to President Richard C. Maclaurin with funds for the "New Technology" to be built in Cambridge in 1916?

Now there's a new "Mr. Smith," and the generosity of his giving depends directly on the generosity of the alumni.

An unidentified donor, an M.I.T. alumnus, has now pledged to match, dollar for dollar, all increases of between $25 and $1,000 over last year's gifts made to the Alumni Fund. To this end he has established a pool of $500,000.

It works this way: suppose you gave $25 last year and give $75 this year, designated for the "Building 10 Fund" (see right). The increase in your gift is $50, and "Mr. Smith" will match your increase with a $50 gift. His gift, too, will be designated for the "Building 10 Fund." Your $25 has grown to $125.

If you work for a company that matches its employees' gifts to universities, your company will also increase accordingly its matching gift to M.I.T. (But "Mr. Smith" will *not* match that increase.)

Another example: if you give $50 this year but gave nothing last year, "Mr. Smith" will match your increase with a $50 gift.

If 10,000 alumni act according to these examples, "Mr. Smith" will use up his pool. And M.I.T. will be $1 million richer — $500,000 from the alumni, and $500,000 from "Mr. Smith." If that level of giving continues, M.I.T. will be richer by $1 million every year — $10 million in a decade.

The goal of "Mr. Smith's" challenge is two-fold, says Paul P. Shepherd, '53, Chairman of the Alumni Fund Board: to encourage alumni who give regularly to M.I.T. to increase their level of giving; and to encourage alumni who have never given to do so. The median gift to the Alumni Fund is now only $25 to $30, and that should be doubled. Just over 20,000 alumni now give each year, and by 1980 that number should be 35,000. Only 675 individuals have given cumulatively $5,000 or more to M.I.T. in their lifetimes, Mr. Shepherd notes; 550 of them are alumni. Gifts of only $500 a year for ten years would bring a person into this "exalted" group. "The Challenge Gift Program could easily expand the present 550 major donors by a factor of 20 or more," says Mr. Shepherd.

Cover:
An informal regatta — held despite the rain — followed the dedication of a renovated and expanded sailing pavilion (see page A6).

Professor David Wilson demonstrates his bike which he uses to commute from his home in Cambridge. On his way he delights in peoples' response — from questions, to requests for a model for sale, to spontaneous applause.

"At first I didn't think I would be able to ride it, but in a week I had the feel."

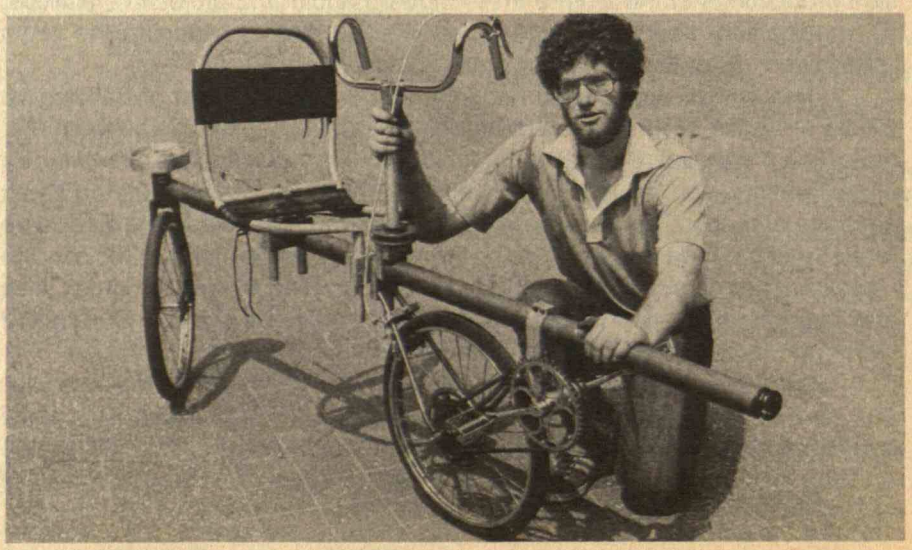
The Bicycle — Made With Imagination

Lee H. Laiterman, '77, wanted a bike that would be comfortable for long-distance traveling. David Gordon Wilson, Professor of Mechanical Engineering, wanted a bike that would be safe for commuting in city traffic. Neither felt their needs were met by the conventional bike. And both are mechanical engineers who are not awed by the overwhelming similarity of bike designs for the last 75 years. ("If a car was built with the same reliability as a bike," says Mr. Laiterman, "it wouldn't get 20 feet out of the garage.")

"My approach began from the physiology of the rider," he explains, "and I designed the bike that logically followed." (He feels the bike industry seriously ignores the rider.) After researching the problem intermittently for two years, a Clapp and Poliak Engineering Design Award through M.I.T.'s Undergraduate Research Opportunities Program (U.R.O.P.) enabled him to devote full time last summer to his design. By August he could be seen teetering through McDermott Court on his prototype, causing some twisted necks as passersby gawked.

"At first I didn't think I would be able to ride it," he admits, "but in a week I had the feel. There is an enormous amount of psychology involved in the rider's interaction with the bike and how he or she takes cues from the road, which doesn't show up on paper," says Mr. Laiterman. His bike takes a whole new set of reflexes; he feels it would be easier for someone who does not ride a conventional bike to learn to ride his.

Without prejudice, Mr. Laiterman took different features of different bikes and combined them, says his advisor, Woodie C. Flowers, Class of 1922 Career Development Professor and Associate Professor of Mechanical Engineering. The specifics of the result: a semi-recumbent rider (this looks like a person relaxing in an easy chair) who is low to the ground (for less air



Lee Laiterman, '77, displays his prototype. Its most controversial feature is rear-wheel steering.

resistance — a crucial improvement over the conventional bike, says Mr. Laiterman); normal size wheels (although the prototype had smaller wheels); a curved center bar (although the prototype had a straight bar); pedal axis 15 inches above the ground; seat 19½ inches above the ground; wheel base 35 inches; steering ratio 2½ to one; steel tubing and aluminum fittings in the prototype (which weighs 45 pounds although the final version will be aluminum alloy weighing about 20 pounds); and — most striking — rear-wheel steering (a steel cable is attached to a pulley mounted horizontally over the back wheel.)

Why rear-wheel steering? Mr. Laiterman knew it was regarded with scepticism, but had never been proved unacceptable. (Professor Flowers pointed out that if one can ride a unicycle — he learned in eight hours — then nothing is impossible.) "To get the rider low, in the position I wanted, and still have a short wheel base, the front wheel must be between the rider's legs," says Mr. Laiterman, "and it's easier to transmit steering than power to the rear."

Pluses of Mr. Laiterman's bike: it is much safer, he says, to have the driver's head away from the probable point of impact in a collision; it can be more maneuverable (to make the same turn the rider needn't lean so much); there is some argument that blood circulation is better in the recumbent position and it is less tiring than the hunched-over posture; because of its simpler frame it can be made into a fold-up model, to be taken apart and put in the trunk of a car.

Also unique — but quite different from the Laiterman model — is Professor Wilson's bike (built by Fred Wilkie according to Wilson's design and called the Green Planet Special.) It has already gone through three evolutions, and a fourth is in progress.

The Wilson bike is controlled by handle bars positioned under the rider's buttocks; the front wheel is about half the size of the rear wheel, which is normal bicycle size; the pedals are far forward of the seat, instead of directly below; and the chain drive to the rear wheel is more than twice as long as on a normal bike. Professor Wilson feels his bike is more comfortable (sitting at a traffic light is like sitting in a garden chair); the rider's hands are always in a relaxed position; and, like the Laiterman bike, the rider's position is safer.

Mr. Laiterman has not yet often ridden his bike out of the confines of M.I.T. David Wilson has — he uses his to commute from his home in Cambridge. And people on Brattle Street burst into spontaneous applause; drivers leap out of trucks to get a closer look; cops stop him — to talk about his bike. His original fear of being a laughing stock turned into delight when the response to his bike was overwhelmingly friendly.

David Wilson worked at The Boeing Company in Seattle, Wash., in 1956 and '57 when, he says, no adults commuted on bikes. Out of 15,000 employees, he was the only cyclist. "I locked my bike right next to the president's office," he recalls. "The others had a ten-minute car ride and a 20-minute walk from the huge parking lot."

In 1967 he sponsored a competition in England to encourage improvements in bicycle design because, he says, in the last two decades of the 19th century almost all of the details of the modern bike design evolved. It has been almost at a standstill since. He feels one reason may be that good designers were attracted by the auto industry. Professor Flowers adds that in many cases big companies are conservative because of pressure from product liability suits.

It is suspected that M.I.T.'s Mechanical Engineering Department harbors some innovative bike-design enthusiasts who are not daunted by strange proposals; their verve is not cooled by the monotony of standard bike designs. Professor Flowers and Stephen C. Jacobsen, Ph.D. '73, of the University of Utah, have an idea (it can be found on the U.R.O.P. list) for a design project to intrigue them: can you imagine a walking bicycle — a ten-speed quadruped — that could shift into a gallop or a trot? . . . — *M.L.*

Can you imagine a walking bicycle — a ten-speed quadruped — that could shift into a gallop or a trot?

Professor Wilson feels that there have been no real design changes in bicycles since 1900. And it appears that this turn-of-the-century cyclist offers a convincing example.

Jack Wood (top, left) captivated an appreciative audience at the sailing pavilion dedication with reminiscences of the beginnings of sailing at M.I.T. George Warren Smith, '26, Sponsoring Committee Chairman, and Olin J. Stephens II, '30 (top, right), toast; and Mr. Smith accepts a surprise presentation of the George Warren Smith trophy from Howard W. Johnson, Chairman of the Corporation.

Expanded Sailing Pavilion Dedicated: Reminiscences, Thanks and an Informal Regatta

The weather was raw, rainy, windy, gray, mean. But that didn't stop a jubilant crowd (of about 400) from filling the newly renovated Walter C. "Jack" Wood, '17, Sailing Pavilion, champagne and hors d'oeuvres in hand, to celebrate its naming and dedication on October 2.

They were warmed by reminiscences by Jack Wood, '17, M.I.T.'s first Sailing Master who is now known as "the father of intercollegiate sailing."

He talked of when, as an undergraduate, he used to sail across the river to M.I.T. from his Beacon Street fraternity and then — to make sure his boat wouldn't be stolen — carry the rudder around all day.

He recalled the decision to name the original boat house. "We didn't want a "yacht club" — that was too exclusive. We wanted something for everyone, so we started the M.I.T. Nautical Association. What to call the building? Sailing Pavilion was quietly chosen. Some people objected. But by then it had to be — the name was already carved in stone."

Mr. Wood's words reached an appreciative audience. Many of them were among the thousands of students who learned to sail at M.I.T. during Mr. Wood's 27 years as Sailing Master. And for at least hundreds of students it was an introduction to a totally absorbing life-long hobby. One recent alumna, Sandra G. Yulke, '74, came away from the ceremony with more than she had expected. She realized that the people she met at the dedication enjoyed sailing at M.I.T. enough to contribute to future generations. And she felt that "being an alumna did not mean that M.I.T. was really over for me, but rather that a whole new relationship was just beginning."

Sponsoring Committee Members Honored

The new fleet of 30 lighter and stronger dinghies and four additional Larks will be housed in the modernized pavilion. Construction included adding 1,800 square feet of dock space, 1,000 feet of boat storage area, new locker rooms, counter-weighted lifting arms for the boats, new cabinets, and a shore school room. ("Twice the size of the one we used to have," says a delighted Harold "Hatch" Brown, Jr., Associate Director of Sailing and varsity coach.) The pavilion interior is now 25 per cent larger.

All this is the result of tireless efforts by George Warren Smith, '26, Chairman, and his Sponsoring Committee, who reached a $300,000 goal. Mr. Smith was presented with the M.I.T. Nautical Association's Distinguished Service Award for 1976, and he was honored by the renaming of the M.I.T.

Open — now the George Warren Smith Open. The winner receives the George Warren Smith trophy.

The reunion classes of '26 (of which Mr. Smith is secretary) and '51 each gave over $50,000 to be used for the construction of new wings for the pavilion. And Mr. Wood's class of '17 contributed over $25,000.

Among members of the Sponsoring Committee: Halsey C. Herreshoff, '60, who modified the Tech Dinghy prototype for the new M.I.T. fleet and is the grandson of Nathaniel Herreshoff, builder of the original Tech Dinghy; and Olin J. Stephens II, '30, designer of five America's Cup winners. He was honored with the presentation of the Olin J. Stephens II Commodore's Room in the new pavilion. (Five donors chose to name their Larks after five America's Cup winners he designed: *Courageous, America, Constellation, Columbia* and *Intrepid.)*

Walter C. "Jack" Wood, '17, served as honorary Chairman of the Sponsoring Committee. Other members included Sumner A. Long, '47, owner of *Ondine II,* one of the fastest racing yachts in the world; Daniel D. Strohmeier, '34, a well known ocean racer and a retired vice president of Bethlehem Shipbuilding Company; and Stephen J. Cucchiaro, '74, winner in 1973 of the Prince of Wales Trophy, one of five North American yachting championships. (He was the first collegian in the history of North American sailing to win the trophy.)

The renovated shore school has been named in honor of Gerald M. Reed, Jr., '34, M.I.T.'s sailing master for 13 years who retired last June.

First on the Charles — and in the United States

In the spring of 1936 the original wooden Tech Dinghies, designed by Professor George Owen, '94, arrived while the pavilion was still under construction. The M.I.T. Nautical Association became the first sailing club on the Charles — as well as the first collegiate sailing facility in the United States.

Under Mr. Wood's direction, M.I.T. gained prominence in North American racing, including representation at the U.S. Olympics. He was a charter member of the Intercollegiate Yacht Racing Association's Hall of Fame at the U.S. Naval Academy.

After the dedication ceremony, the weather didn't keep enthusiastic sailors off the water — the new dinghies were tested in an informal regatta. The top scorer was *Cricket,* sailed by Austin "Wally" Corwin, '78, the grandson of I. Austin Kelly, '26, who donated the boat. Others sailing the boats they donated: John Marvin, '49, Olympic yachting medalist, sailed *Aero;* Peter Felsenthal, '54, and his wife (who came from Cleveland for the dedication) sailed *Alert;* Daniel D. Strohmeier, '34, Long Island Sound frostbiter, sailed *Malay* (this is the fourth boat in the family of that name); Gerald Marcus, '51, and his son Edward sailed *Marc 3;* John B. Lawson, '50, sailed *Amee,* John Fennessey, '47 (who came from Detroit for the dedication) sailed *Intrepid.*

Others in the Rededication Regatta: Steven J. Cucchiaro, '74, (twice college sailing All American) who came in second in *Stereo Three;* Terry L. Cronburg, '66 (college sailing hall of fame) who sailed *Beaver* and came in third; Howard H. Fawcett, Jr., '52, sailed *Instron* and came in fourth; Jerome H. Milgram, '61, Professor of Naval Architecture, sailed *Ondine;* Maria A. Bozzuto, '73, M.I.T.'s top woman sailing performer to date, sailed *Maria*; Joseph I. Smullin, '66, (former sail team captain and the son of Professor Louis D. Smullin S.M., '39) sailed *Cerium;* Morton S. Bromfield, '46, (sponsoring committee member) sailed *Tweetie K;* Robert B. Nickerson, '51, sailed *Windborne;* Cyrus H. Kano, '43, sailed *Abraham W. Rizika;* Emily and T. J. Baker sailed *Tee Pee;* Jan A. Northby, '59, sailed *Stars III;* Charles H. Hoffman, '39, sailed *Sualdan;* "Doc" Lukens, '41, (former sailing coach) sailed *Impala;* Patricia A. Clark, '60, sailed *Aquafine.*

For Jack Wood the day was a vision fulfilled. His first words in stepping up to the podium during the dedication ceremony: "This is a dream, I'm sure." — *M.L.*

President Wiesner displays the "token" with which the sailing pavilion was formally dedicated. Not just conjured up for the occasion, it is a five inch bronze model of a yachtsmans anchor, skillfully created more than 40 years ago in the marine hardware shop then owned by Jack Wood. Properly mounted, it will be permanently displayed at the sailing pavilion. Top: new dinghies.

"We can't draw a line and say, here's the Energy Lab and here's M.I.T. . . . And we don't want to."

M.I.T.'s "Mr. Energy" Runs Nation's "Best Lab"

A scientist's total absorption in one esoteric project often assures isolation from researchers who hold a different — and perhaps important — perspective on the same puzzle.

Not so at the M.I.T. Energy Laboratory. "Projects that draw on cross-disciplines are our strength," says Professor David C. White, Director of the Energy Laboratory and Ford Professor of Engineering.

Over 100 faculty members and technicians and almost as many students in the Lab draw on expertise in engineering, economics, management, international studies, urban planning, and architecture for their research. The Lab concentrates on energy management and economics, fossil fuel utilization, nuclear and environmental technology, and electric power production.

Established as a focus for energy-related research at M.I.T. in 1972, the Lab was originally envisioned as an on-campus analogue to Lincoln Laboratory — a kind of semi-independent research enterprise devoted to energy technology. Now its interests relate to nearly all Institute research activities — and tie very closely to some. "We can't draw a line and say, 'here's the Energy Lab' and 'here's M.I.T.,' " says Professor White. "And we don't want to draw such a line — we're part of M.I.T."

At first the Lab's administrators adopted the shotgun approach — every good research proposal was encouraged. "It has been interesting fun to see which interdisciplinary combinations work and which don't — often a surprise," says Professor White. Clearly, the Lab's development was shaped, in large part, by the departments that chose to become involved. "M.I.T. has the resources to accept new challenges in many areas," explains Professor White. "For instance, important combustion projects are now underway here. Combustion research has a long history at M.I.T. — dating from 1928. You can pick almost any technical area and find that kind of commitment, invaluable to a facility so young." Often, a student thesis is instrumental in opening an area of research under the Lab's auspices, or a faculty member may join who has experience in a problem and needs the Lab's resources to continue his investigations. One task well done suggests other projects; in this respect, says Professor White, "the Lab is very much a bootstrap operation."

Many of the Lab's projects start as mission-oriented programs. But the immediate problems often prompt basic research, and that in turn leads to exploration of wholly new areas. (For example, original laser research was directed toward an application different from the current one.) "Whole fields may blossom from fundamental research projects now funded," says Professor White.

Work on the carcinogenicity of pollutants grew from the interaction of combustion researchers, toxicologists, and health workers — an example of cross-disciplinary work. More effective health standards in combustion technology is another similar interdisciplinary focus of Energy Lab work. These also demonstrate the changing emphases of M.I.T. faculty. "It used to be that the discovery of a useful product was all researchers cared about," Professor White says. "Now that's not enough."

Some fields have been especially tough — those devoted to energy conservation, for example. "To succeed, we must mix new technology with old, consider the costs, and perceive the people or industry involved with acuity mindful of what's right for them," says Professor White. "Our work on conservation has been modestly unsuccessful; the government's has been totally unsuccessful. One of our challenges is to figure out why."

The Energy Lab now holds about 30 contracts varying from three-months' to three-years' duration and totaling $5 million. "Conducting too many projects at once is a problem," says Professor White. "If we accepted a smaller number of larger contracts, we could lower administrative costs. Larger grants allow a long period of research and so involve more students and faculty. Sometimes small contracts are accepted as a public service to open up a new area and encourage additional funding later on. As a rule, however, small projects are discouraged because they don't serve the Lab's educational function. "There are bound to be periods in between when the staff is idle," explains Professor White.

He feels the Lab is one of the most aggressive in the country. "Only two or three universities have anything comparable; ours is the biggest of them all — and I'd say it's the best." — *M.L.*

"Our work on conservation has been modestly unsuccessful; the government's has been totally unsuccessful. One of our challenges is to figure out why."

Toward a New Level of Alumni Involvement

What can alumni do for and about M.I.T.?

More than most of them imagine. Lots more than just give money.

A new initiative for alumni involvement in M.I.T. — to help in educational programs, housing activities, extracurricular affairs, placement, and advising — was proposed by Claude W. Brenner, '47, Vice President of the Alumni Association, during the 1976 Alumni Officers Conference. His report, the result of a committee study of "multiple communication paths" which might be cultivated between alumni, students, and faculty, produced a catalog of opportunities, new and old, which many A.O.C. "regulars" as well as newcomers found innovative and stimulating.

The Committee to Strengthen Alumni Involvement with the Institute — a long title, for which there is no acronym — focused on a single alumni resource: "that reservoir of skills, talent, interest, and imagination we possess that may be drawn upon to further M.I.T.'s academic goals and enhance the quality of student life."

Here are some of the Committee's ideas for bridging the gap between Institute needs and alumni capabilities as listed by Mr. Brenner:

☐ Alumni membership on doctoral committees examining candidates for M.I.T. doctoral degrees.

☐ Graduate theses performed in industry under joint faculty-alumni supervision.

☐ Visiting and adjunct professorships and other less formal teaching assignments for alumni.

☐ Term-time and summer jobs for students, and help to students seeking full-time jobs upon graduation.
☐ Undergraduate research projects under the Undergraduate Research Opportunities Program (U.R.O.P.) supervised by alumni and conducted in their plants and laboratories.
☐ Expansion of the cooperative programs into industries and companies in which alumni are principals.
☐ Hospitality and counseling for students in the Boston area.
☐ Convocations to bring alumni to the campus and into communication with faculty and students.
☐ Special assistance and counseling by alumni to undergraduate activities in which they are especially interested.

To start things moving, the Committee to Strengthen Alumni Involvement with the Institute proposed the designation of Course Liaison Officers — alumni designated to work with department heads to identify needs and interests.

"The menu is rich and varied," said Mr. Brenner, but he emphasized personal satisfaction by all participants as the key ingredient. "Altruism works only to a point," said Mr. Brenner. "The volunteer alumnus must feel that he is being rewarded for his effort — even though these rewards be intangible — by personal satisfaction, heightened self-esteem, approbation of one's peers." And the opportunity for continued learning through association with students and faculty seems to Mr. Brenner an intrinsic, measurable benefit.

The admission requirement is not an exam, but simply an intuitive feel for technical things . . .

East Boston's "Magnet" Technical School: A New Concept in Education

There has not been a school like this in the Boston system.

Its facade is new — graffiti-free, gleaming, neatly landscaped. Classrooms form clusters; there are few halls; ceiling soundproofing (a sound shield from Logan Airport traffic overhead) makes an intricate pattern and permeating quiet.

More important, the curriculum is new. The Mario Umana Harbor School of Science and Technology in East Boston is not a vocational school, where traditionally students who have not done well in academic areas are trained in practical "hands-on" specialties, and where academic study is only to complement shop experience. Nor is it the elite "technical" school where carefully picked "brains" are deluged with high-level abstractions in mathematics, science, and engineering, to be snapped up by institutions such as M.I.T. Neither traditional concept is its model.

Planning for the new program began in May, 1975, when U.S. District Court Judge W. Arthur Garrity, Jr. proposed a series of "magnet" schools to improve educational opportunities and turn desegregation into an asset for many Boston students. Judge Garrity linked M.I.T., the Wentworth Institute, and the Massachusetts Port Authority (which operates Logan International Airport in East Boston) to help the Boston School Department create from scratch in a year's time a "magnet" technical school which would serve students from throughout the city. At M.I.T.'s request, other experts from academia and business became involved.

The result: a new definition of "technical" school — as one with a high degree of technical learning that is taking students with a normal range of achievement. The student will be served who wishes to go on to a place like M.I.T., as well as the one who can fulfill his or her goals and abilities by working in a drafting office or hospital laboratory. In fact, the program would be considered unsuccessful if only one of these extremes were satisfied.

Admission requirement is not an exam, but simply an intuitive feel for technical things — and the desire to study them. Says Dr. Stanley Russell, M.I.T. coordinator of the project, "It is hoped students will come here who like

East Boston's "Magnet" technical school serves students from all over Boston who choose a technically-oriented education.

to take things apart and put them back together, some kids who might be eliminated by an exam, and some who would pass it, but all of whom can be successful if we can pick them up and build on what they have." Strong remedial programs will be provided, especially in reading and mathematics. Dr. Alan Natapoff, Research Associate in Aeronautics, spends several days a week at the school training teachers in the use of special remedial mathematics techniques that he and his associates have developed.

Emphasis is placed on the study of aviation (from ground equipment support to aeronautical engineering), computer science (the thread to tie everything together), electronics, environmental protection, and medical technology. Some 130 people were involved in planning the curriculum, about two-thirds of whom were affiliated with M.I.T. Inputs came from a variety of sources. The aviation curriculum, for instance, was developed by a team of two aviation science specialists from M.I.T., one from Wentworth, a Federal Aviation Agency representative, an expert from American Airlines, a member of the Logan Airport noise abatement team, and an aviation teacher from a suburban school.

"We are infusing the usual school curriculum with an ambience that identifies it as a technical school."

Some graduates may wish to go into liberal arts — and they will be ready for that, too. "We are infusing the usual school curriculum with an ambience that identifies it as a technical school," says Barbara S. Nelson, Assistant to the President and Chancellor. Social studies, for instance, can also reflect technical interest. M.I.T. Professor Louis L. Bucciarelli, Jr. was working on a good example of this — he feels a student can study the history of New England by following the development of technology in typical New England towns. So Dr. Russell recruited him as a prime consultant for the social studies program.

It is hoped that students will gain a grasp of being a citizen in today's technology-oriented world as well as a solid background in math and science that is appropriate for either college or the job market. This will be done in a variety of ways. For example, the students will have access to computers; each user's program stored in the memory bank will be available only to him or her. This concept of privacy will hopefully spill over from the level of self to a broader awareness of computers and privacy in our society.

Grades seven through 12 will eventually be housed in the new school; this year grades seven through ten are there. (The building was originally designed for children in grades six through eight but is being adapted for older students.) Within two years, the complete high school program will be part of the curriculum.

Technically-oriented students from all over Boston have been invited to choose the Mario Umana Harbor School of Science and Technology. They have created a desegregated school without the stigma of forced busing (that has been the subject of protest for two tumultuous years in Boston.) Like other "magnet" schools, "the Harbor School will attract a full range of kids," says Walter L. Milne, Special Assistant to the President for Urban Relations, "who are exploring a particular pathway in life." — *M.L.*

Students

Susan L. Kayton, '78, (right) holds the bucket and toy shovel that was her prize as winner of the Sandbox Derby tug of war, a Course 2.70 Introduction to Design contest. She called her entry the Mugger Tugger; it defeated 129 other student-made, rubber-band-power devices. She wound up a spool fashioned from the fiber board made available in the identical parts kits given students by Professor Woodie Flowers, Ph.D. '73, who is in charge of the course. Opposite page: Jeffrey Crothers, '79, and Brad Brewster, '79, set up a tugger.

Slow Rush, Fast Crowd

The Tech called it "the slowest fraternity rush since 1967 . . . a strong preference for dormitories among the Class of 1980." But the fraternities' plight was not really serious — 45 students fewer than estimated averages out to barely more than one too few per house, and that's hardly bad news. The impact on already-crowded dormitories was perhaps more severe: "the greatest crowding we have ever experienced," said Kenneth C. Browning, '66, Associate Dean for Student Affairs, as the Class of 1980 settled in last fall.

Kudos to the Outing Club

As a senior at M.I.T., Arthur H. Reidel, '73, edited a new edition of *Fundamentals of Rock Climbing* for the M.I.T. Outing Club. His work has now helped earn top rating for the Club — it's called "the most prestigious college outing club in the U.S." — from Anne and Steve Schneider, authors of *The Climber's Sourcebook* (Anchor-Doubleday, 1976).

The Schneiders call Mr. Reidel's book an excellent basic rock-climbing manual with "a most important chapter ('Accidents and Associated Problems') covering important leadership errors."

Two Views of the Annual Rite of F.S.N.

F.S.N.? That's a form of ritual baptism which is becoming controversial in the M.I.T. dormitory system. No one knows when the "tradition" began in the Institute Houses, but this year it's matured to claim space in both *The Tech* and *Ergo*.

F.S.N. — Freshman Shower Night — is often the night before the first 8.01 quiz, or alternatively the night before the first 5.41 test. The object is hazing, in a mild form: scores of freshmen are forced — mostly by sophomores — to submit to brief, fully-clothed showers. If your resistance isn't appropriate (except in the case of freshmen who are genuinely upset by the proceedings, says Glenn Brownstein, Editor of *The Tech*), the Chapel moat is regarded as an appropriate higher-level punishment.

Mr. Brownstein takes F.S.N. lightly to task — "stupid, pointless, and a waste of everybody's time, a good way to make intimate contact with the freshpeople you always wanted to meet . . . an initiation rite, a ceremonial baptism into Engineerhood.

But Eric W. Anderson, '79, takes a more serious view: "At a time when freshmen want to be respected as real members of the college community," he wrote in *Ergo*, "they are forced to participate in a childish game in which they must try to escape the gangs of pursuing upperclassmen. The interruption of their study, the stripping of personal dignity in the attack, and the resulting sense of helplessness, all add up to a concerted attack on the freshman's sense of self-esteem. . . . A serious, even vicious, occasion," he thinks.

In a letter to *The Tech*, Peter Buttner, '61, Associate Dean for Student Affairs, sides with Mr. Anderson: "M.I.T. has become a more humane environment over the years, and it would be a big step forward to relegate the Shower Ritual to the anachronisms of the past."

An Analysis of the Safe Skier

Will you be on the injured list at a ski resort this winter? Compare your profile with that of a low injury risk skier: he or she is over 18, experienced, skis alone and on weekdays, uses shorter skis and modern equipment, lubricates and checks ski bindings, avoids fatigue and late afternoon skiing, and skis when conditions are good.

This composite profile came out of a nine-year study by Professor Laurence R. Young of the Man-Vehicle Laboratory in the Department of Aeronautics and Astronautics, and Dr. Henry Crane, instructor in orthopaedics at the Harvard Medical School and chief of staff at the Sceva Speare Memorial Hospital in Plymouth, N.H. M.I.T. students Ross J. Heide, '76, Peter Hobbs, graduate student, and Johannes B. Nye, '77, provided technical assistance.

After analyzing a total of 5,248 accidents at the Waterville Valley ski area in New Hampshire from 1966 to 1975, the researchers concluded:

☐ Advanced skiing ability is the single most important factor in avoiding injury.

☐ Weekends are by far the most dangerous time for skiing.

☐ Injuries increase as the crowd size increases (but actual collisions are not a major factor in the increase.) Although weekday and weekend skiers were found to be well-matched in terms of ability, experience, gender, and age, it appears that the increased injury rate on weekends was caused by many factors: the relaxed attitude of the weekday skier (on weekends lift lines cut down skiing time — and skiers feel they can't afford to take a break); the considerable amount of race and free-style practice and competitions on weekends; the snow conditions getting worn down much earlier; and people attempting to ski in places where they don't belong.

☐ Skiing conditions are factors in 20 per cent of all accidents.

☐ Fatigue is an important contributory factor in ski accidents.

☐ Younger skiers up to the age of 18 are far more likely to be injured.

☐ The introduction of high, stiff ski boots has brought about a drop in ankle injuries.

☐ Most skiers stay on trails appropriate to their abilities.

☐ Skiers who test and adjust their bindings themselves have a lower injury rate than those who have it done in a shop.

☐ Skiing in groups leads to more injuries than skiing alone, possibly through attempts to "show off" or because of pressure on poorer skiers to keep up.

The study was the winner of the 1976 United States Ski Association Award for Ski Injury Research.

What do you do for publicity when the donors of $2 million in scholarships and fellowships come to visit their beneficiaries? Here are two answers by Calvin Campbell of the M.I.T. News Office. (top) A chorus line of women graduate students, all Ida M. Green Fellows, with the donors, Dr. and Mrs. Cecil H. Green. No accident that the picture was made with the Cecil and Ida Breen Building (earth sciences) as a background; Dr. Green, Honorary Director of Texas Instruments., Inc., was founder of T.I.'s predecessor company, Geophysical Services, Inc., shortly after graduating from M.I.T. in the Class of 1923. (above) A toast by Mrs. McDermott (center left) for three recipients of the Eugene and Margaret McDermott Scholarships; the students are David York, '80, Diana L. Daniels, '79, and Paul M. Haines, Jr., '78, and with them are Mr. and Mrs. Edward O. Vetter. Everyone in the picture is from Dallas, Texas; Mr. Vetter, who is a member of the Class of 1942, is Under Secretary of Commerce.

New Movie Stars Old Heroes

Technique Rush, class day activities in the '20s, aerial acrobatics filmed from the cockpit by Charles Stark Draper, '26, the blimp used for weather experiments at the Round Hill Observatory . . . The montage of silent film skittering by summoned nostalgic memories for old-timers attending the Alumni Officers Conference dinner in mid September; and everyone there witnessed the heroes that reverberate throughout M.I.T.'s history from 1900 to 1950.

The film, "1900-1950" — given its premiere at the A.O.C. — was the production of David Karp, '78, who matched up his interest in history — though he is a chemistry/applied biology major — with his freshman advisor Warren Seamans, Director of the Historical Collections. When Warren asked him to sort through a box of films, "just to see what's there," David found what he calls "a fascinating chronicle of M.I.T. through the actions of those people who made its history." Raids on closets and attic storerooms throughout the Institute produced a total of over 250 films which have now been collected and indexed in the Historical Collections.

This valuable resource became the basis for what Warren Seamans envisioned as "a self-explanatory Institute document" which would gain wide use at alumni gatherings or as an introduction to M.I.T. for students and employees. David learned the techniques for cleaning and restoring film — some of which had been blistering in 110-degree temperatures for 40 years — and wrote a script to tell the story of "how the people helped to shape the Institute to become what it is today."

David's original film, "Take Me Back to Tech," brought the chronicle up to the present. But a comprehensive portrayal of the years after the middle of the century proved impossible. "After 1950, M.I.T. became a very complicated place," explains Warren Seamans. There are innumerable fields of interest that would merit inclusion in such a film and a dearth of material on recent years.

So shortly before the Alumni Officers Conference, David reoriented the film to M.I.T.'s earlier years — the most interesting

The film "1900-1950" was premiered at the Alumni Officers Conference in October. It was the production of David Karp, '78 (left in left photo), who — with the assistance of Warren Seamans, Director of the Historical Collections (right) — collected over 250 films throughout the Institute and distilled them in one film, a voyage through M.I.T. to mid-century. One of the stars of his film was Ralph Adams Cram, a professor in the Department of Architecture, who presented a pageant — in which he presided as Merlin (in right photo) — for the dedication of the new Cambridge campus in 1916.

and creative films were made in the 1920s and 1930s — and held a trial run for the reunion of the Class of 1918 at Endicott House. "They loved it," recalls Warren Seamans, who plans to show the film to the M.I.T. clubs in Florida in November. — *S.F.*

The Stein Club Launches Its Wiesner Scholarships — $500,000 by 1977

A new scholarship fund named in honor of President Jerome B. Wiesner has been launched by the Boston Stein Club, and Oscar H. Horovitz, '22, the Club's fund-raising chairman, says the initial goal is a total of $100,000.

To date members of the Stein Club have contributed at least $400,000 to M.I.T. scholarship and loan funds. "Now," says Mr. Horovitz, "we want to increase our effort dramatically, significantly — not only in order to help more needy students but through them to honor one of the great leaders in scientific and engineering education."

The Alumni Fund's matching gift program *(see page A3)* provides an added incentive: the amount of gifts to the Wiesner Scholarship fund which exceed last year's giving by the same donor will be matched by the anonymous challenge fund donor; and this challenge fund contribution as well as the gift of the alumnus, will be credited to the Wiesner Scholarship.

Gifts to M.I.T. credited to activities of the Boston Stein Club and its members are now approaching a total of $500,000. They include $39,000 for prizes and grants honoring Karl T. Compton, a $15,000 freshman loan fund, over $33,000 to equip and endow the map room in the Hayden Library and $393,000 for freshman scholarships (to which the Wiesner fund will be a supplement).

Technology Day, 1977

The emphasis for Technology Day, this year on June 10, 1977, will be on young faculty members' research. Samples: resources of the ocean; planetary explorations with photos the public doesn't usually get a chance to see; a discussion of the use of computers in music composition; an electrostatic separation system for air pollution; management and technological innovation. The Tech Night at the Pops will be Thursday, June 9; there will be reunions during the week and weekend; the annual Alumni Day luncheon on June 10 will include class gift presentations. Call the Alumni Association collect to be placed on the mailing list: (617) 253-3879.

Sponsored Research Forecast: Up 13.2 Per Cent

On-campus sponsored research — not including subcontracted work — will total $106 million in 1976-77, according to estimates by Robert M. Dankese, Assistant Director of the Fiscal Planning and Budget Office. That's an increase of $12.3 million (13.2 per cent) from the level of sponsored programs in 1975-76.

Of the total, $87.5 million will come from federal sources, including $22.9 million from the National Science Foundation, $20 million from the Department of Health, Education and Welfare, $18 million from the Energy Research and Development Administration, and $13.6 million from the Department of Defense.

Research volume at Lincoln Laboratory, excluding subcontracts, is forecast at $83.9 million in 1976-77, up $1.5 million (1.8 per cent) from 1975-76.

A New Fusion Research Center

The success of M.I.T.'s Alcator, a "tokamak" fusion machine (*see* Technology Review *for May, pp. 23-24*), and the broad interest in many Institute departments in the science and technology of fusion power, have together sparked the formation of a Plasma Fusion Center. It will be "an intellectual and administrative focal point for work in plasma physics and fusion," says Albert G. Hill, former Vice President-Research, who will serve as Director pro tem of the new Center. One of his principal tasks will be to find a new permanent director.

Just a year ago Alcator achieved the best containment of high-temperature plasma by any fusion device thus far built in the U.S. Now a new, larger Alcator is being built in the Bitter National Magnet Laboratory with major funding from the Energy Research and Development Administration.

Estimated Sponsored Research Volume,* 1976-77 (millions of dollars)

The volume of sponsored research on the campus is forecast to be 13.2 per cent higher in 1976-77 than in the previous year. The table shows departments and interdepartmental laboratories with forecast volumes of $2 million and over during the current year.

Laboratory for Nuclear Science	$8.18
Bitter National Magnet Laboratory	7.37
Research Laboratory of Electronics	6.63
Energy Laboratory	6.14
Department of Nutrition and Food Science	5.49
Department of Biology	4.88
Department of Chemisty	4.86
Department of Mechanical Engineering	4.49
Department of Materials Science and Engineering	4.3
Laboratory for Computer Science	3.84
Center for Space Research	3.84
Department of Earth and Planetary Science	3.74
Department of Aeronautics and Astronautics	3.3
Department of Civil Engineering	3.01
Department of Electrical Engineering and Computer Science	2.93
Center for Cancer Research	2.21
Haystack Observatory	2.03
Department of Physics	2.01

* Not including subcontracts.

A Roster of M.I.T. Clubs and Their Presidents

When you're traveling and want some M.I.T. fellowship, a letter or phone call to any of these alumni will put you in touch with the action and where it's happening. The list gives the name of the president of each M.I.T. club in the U.S.; a similar list of overseas clubs will appear in the *Review* for January.

Alabama
M.I.T. Club of **Birmingham** — David Thurlow, '41, 2604 Caldwell Mill Lane, Mountain Brook, Ala., 35213; (205) 967-2613.

Arizona
M.I.T. Club of **Arizona** — Robert T. Marsh, Jr., '66, 17118 E. La Pasada Drive, Fountain Hills, Ariz., 85268; (602) 837-1874.

California
M.I.T. Club of **Northern California** — Robert K. Ramers, 17 Eton Way, Mill Valley, Calif., 94941; (415) 383-6516.
M.I.T. Club of **San Diego** — Jerry E. Cook, S.M. '71, 5991 Howell Drive, La Mesa, Calif., 92041; (714) 459-2360.
M.I.T. Club of **Southern California** — Ray O. Wyland, Jr., '42, 7123 Estepa Drive, Tujunga, Calif, 91042; (213) 353-0923.

Colorado
M.I.T. Club of **Denver** — Gordon W. Moore, '60, 2244 S. Milwaukee Street, Denver, Colo., 80210; (303) 757-8052.

Connecticut
M.I.T. Club of **Fairfield County/Westchester** — Rolf Kates, '54, 37 Pumpkin Hill Road, Westport, Conn., 06880; (203) 221-6591.
M.I.T. Club of **Hartford** — Laurence Boedeker, '52, 18 Birch Road, West Simsbury, Conn., 06092; (203) 565-8950.
M.I.T. Club of **New Haven** — Hillel J. Auerbach, '58, 522 New England Lane, Orange, Conn., 06477; (203) 795-5451.
M.I.T. Club of **New London** — Russell W. Brown, '42, 158 Old Black Point Road, Niantic, Conn., 06357; (203) 739-8152.

Delaware
M.I.T. Club of the **Delaware Valley** — see Pennsylvania.

District of Columbia
M.I.T. Club of **Washington** — Achilles Adamantiades, '66, EPRI, 1750 New York Avenue, N.W., Washington, D.C., 20006; (202) 872-9222.

Florida
M.I.T. Club of **Central Florida** — Donald E. Robison, '46, Ro-Mo Color Laboratory, Inc., Box 1011, St. Petersburg, Fla., 33731; (813) 822-4336.
M.I.T. Club of **Jacksonville** — E. Newton Roberts, '26, 1320 Atlantic Ave., Fernandina Beach, Fla., 32034; (904) 261-5239.
M.I.T. Club of **Miami** — Russell L. Law, Jr., '48, 255 Alhambra Circle, Coral Gables, Fla., 33134; (305) 448-5666.
M.I.T. Club of **Orlando** — George W. McClary, '51, 326 Fitzhugh Road, Winter Park, Fla., 32789; (305) 671-2017.
M.I.T. Club of **Palm Beach** — John Chamberlain, '44, 8141 S. Elizabeth Avenue, Lake Park, Fla., 33410; (305) 844-7311.
M.I.T. Club of **Southwest Florida** — Robert D. Butler, '32, 7263 Plovers Way, Sarasota, Fla., 33581; (813) 349-1392.

Georgia
M.I.T. Club of **Atlanta** — Morton M. Gruber, '58, Gruber and Associates, Inc., 100 Peachtree Street N.W., Atlanta, Ga., 30303; (404) 577-9176.

Hawaii
M.I.T. Club of **Hawaii** — Kim C. M. Sloat, '64, 1850 Makuakane Street, Honolulu, Hawaii, 96817; (808) 842-8301.

Illinois
M.I.T. Club of **Chicago** — Richard A. Jacobs, '56, A. T. Kearney, Inc., 100 South Wacker Drive, Chicago, Ill., 60606; (312) 782-2868.

Kansas
M.I.T. Club of **Kansas City** — James F. Hield, '44, Lake Quivira, Kansas City, Kans., 66106; (913) 631-2855.

Louisiana
M.I.T. Club of **New Orleans** — Richard M. Adler, '48, 1109 State Street, New Orleans, La., 70118; (504) 776-2121.

Maine
M.I.T. Club of **Eastern and Northern Maine** — John J. Dunn, '27, Reach Road, Sedgewick, Me., 04676; (207) 359-8965.
M.I.T. Club of **Portland** — Robert A. Lindquist, '51, 15 Ramble Road, Cape Elizabeth, Me., 04107; (207) 854-9721.

Maryland
M.I.T. Club of **Baltimore** — Lawrence Kuszmaul, Jr., '51, 5178 Orchard Green, Columbia, Md., 21045; (301) 730-6098.

Massachusetts
M.I.T. **Boston Stein Club** — Carney Goldberg, '28, 300 Allendale Road, Chestnut Hill, Mass., 02167; (617) 523-1328.
M.I.T. Club of **Boston** — David S. Prerau, '70, 872 Massachusetts Avenue, Cambridge, Mass., 02139; (617) 494-2414.
M.I.T. Club of **Cape Cod** — F. Leroy Foster, '25, Box 331, North Chatham, Mass., 02650; (617) 945-2236.
M.I.T. Club of **Fall River** — Albert A. Stewart, '32, 223 Howland Road, Adamsville, R.I., 02801; (617) 997-9321.
M.I.T. Club of **Framingham** — Harry Movitz, '63, 39 Carter Drive, Framingham, Mass., 01701; (617) 877-0125.
M.I.T. Club of **New Bedford** — Martin S. Lindenberg, '39, 20 Emerald Drive, North Dartmouth, Mass., 02747; (617) 992-8951.
M.I.T. Club of **Pittsfield** — A. Kelly Hooks, '53, Blair Road, Williamstown, Mass., 01267; (413) 664-4411.
M.I.T. Club of **Springfield** — Vincent P. Mango, '31, 76 Patricia Circle, Springfield, Mass., 01129; (413) 782-4262.
M.I.T. Club of **Worcester** — Irvine F. Williamson, '50, 8 Heatherwood Drive, Shrewsbury, Mass., 01545; (617) 853-1000.

Michigan
M.I.T. Club of **Detroit** — Dale R. Small, '54, Whittemore Hulbert and Belknap, 3453 City National Bank Building, Detroit, Mich., 48226; (313) 962-6192.

Minnesota
M.I.T. Club of **Minneapolis** — William J. McGinnis, '66, 7321 Faricy Lane, Prior Lake, Minn., 55372; (612) 853-3267.

Missouri
M.I.T. Club of **St. Louis** — James Maguire, '38, 1132 Whitecliff Drive, St. Louis, Mo., 63122; (314) 821-0093.

New Hampshire
M.I.T. Club of **New Hampshire** — William G. Drew II, S.M. '62, 25 Wood Street, Nashua, N.H., 03060; (603) 882-3946.

New Jersey
M.I.T. Club of **Northern New Jersey** — Terrence K. McMahon, '57, 47 East Ruby Avenue, Palisades Park, N.J., 07650; (201) 444-0520.
M.I.T. Club of **Princeton** — Leonard F. Newton, '49, 90 Dempsey Avenue, Princeton, N.J., 08540; (609) 924-0861.

New York
M.I.T. Club of **Buffalo** — Leonard W. Golden, '55, Colgate Plastics Corporation, 162 Colgate Avenue, Buffalo, N.Y., 14220; (716) 823-6365.
M.I.T. Club of **Fairfield County/Westchester** — see Connecticut.
M.I.T. Alumni Center of **New York** — 50 East 41st Street, New York, N.Y., 10017; (212) 532-8181; Eugene D. Becken, '52, 52 Rutland Road, Glen Rock, N.J., 07452; (201) 444-0520.
M.I.T. Club of **Rochester** — Donald J. Spooner, '52, 550 Wahlmont Drive, Webster, N.Y., 14580; (716) 325-2000.
M.I.T. Club of **Schenectady** — Bruce W. Wessels, '73, 2305 Stuyvesant Drive, Schenectady, N.Y., 12307; (518) 346-8604.

Ohio
M.I.T. Club of **Cleveland** — Noel S. Bartlett, '60, 15320 Edolyn Avenue, Cleveland, Ohio, 44111; (216) 252-1874.

Oklahoma
M.I.T. Club of **Oklahoma** — Curtis S. Green, '48, 7305 East 67th Place, Tulsa, Okla., 74133; (918) 583-7181.

Oregon
M.I.T. Club of **Portland** — William L. Carey, 10968 S.E. 66th Avenue, Milwaukie, Ore., 97222; (503) 654-8515.

Pennsylvania
M.I.T. Club of the **Delaware Valley** — Robert F. St. Aubin, '64, 931 Clover Hill Road, Wynnewood, Penn., 19096; (215) 299-6995.
M.I.T. Club of the **Lehigh Valley** — James M. Goldey, '66, 208 Azalea Road, Allentown, Penn., 18103; (215) 439-7361.
M.I.T. Club of **Western Pennsylvania** — Martin Wohl, '53, 7520 Carriage Lane, Pittsburgh, Penn., 15221; (412) 621-2600.

Rhode Island
M.I.T. Club of **Providence** — Herbert L. Spivack, '49, 50 Birchwood Way, East Greenwich, R.I. 02910; (401) 885-1563.

Texas
M.I.T. Club of **Northern Texas** — Joseph Zimmerman, '59, Texas Instruments, Inc., 1350 N. Central Expressway, Dallas, Texas, 75231; (214) 238-2011.
M.I.T. Club of **South Texas** — Samuel C. Stephan, Jr., '50, 18502 Capetown Drive, Houston, Texas, 77058; (713) 483-2605.

Washington
M.I.T. Club of **Puget Sound** — Thomas P. Rona, '53, 5770 63rd Avenue, N.E., Seattle, Wash., 98105; (206) 634-1324.

Wisconsin
M.I.T. Club of **Milwaukee** — A. George Abbott, Jr., '53, 12563 North Jacqueline Court, Mequon, Wis., 53092; (414) 447-4000.

A New Home for the Draper Laboratory

The Charles Stark Draper Laboratory, Inc., began life as the Instrumentation Laboratory in a rented shoe-polish factory back of M.I.T. Since then, recalls its founder, "we've never owned anything and we never expected to own anything." His office was "a broom-closet where I could keep my papers and second-hand equipment."

But that's all changed now. On September 10 Charles Stark Draper, '26, found himself holding a symbolic key to a "great monster" of concrete and glass which would be devoted wholly to the needs of C.S.D.L. It was the beginning of a new era for the Laboratory, whose President is now Robert A. Duffy (Dr. Draper is retired but active in his post as Senior Scientist): a new building in Technology Square just north of the M.I.T. campus in Cambridge.

Dedicating the building, Robert C. Seamans, Jr., Sc.D. '51, who studied with Professor Draper 30 years ago and now has major national responsibilities as Director of the Energy Research and Development Administration, drew this lesson from his association with his former teacher: "If you want to learn how to play baseball, you've got to get out in the field. If you want to be an oceanographer, you've got to go out to sea. In each case, you've got to be working with people who know the game.

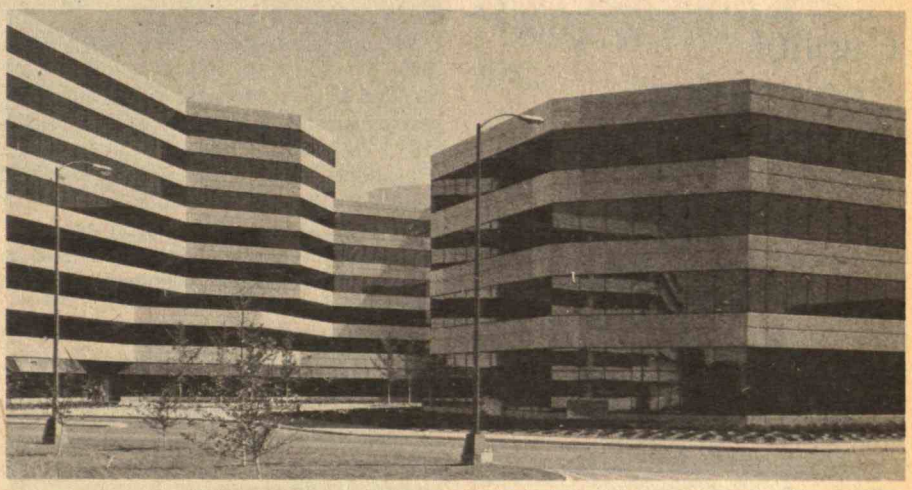
"And so it is with gyros and accelerometers and other kinds of advanced technology. If you want to learn about them, there's no greater opportunity than working in the Draper Laboratory. As 'Doc' says, 'I've always been primarily interested in going all the way with technology, which closes the gap between basic knowledge and the needs of society.' "

Looking at the Legionnaires' Hair

A scanning proton microprobe being developed by an M.I.T.-Harvard team at Lincoln Laboratory made headlines this fall when samples of hair from victims of "legionnaires' disease" were flown to it for analysis. The results: negative, or inconclusive.

In the microprobe, a tiny beam of protons is made to irradiate an unknown specimen, causing the various elements present to emit x-rays of characteristic energies. The elements are identified by the x-ray signatures they demonstrate.

In the case of the legionnaires' disease, the idea was to identify poisonous minerals or other elements which might be present in excessive amounts in the victims' hair strands. The analysis at Lincoln Laboratory confirmed that no materials known to be detectable in hair — arsenic, mercury, and lead — were present in toxic amounts. Nickel carbonyl was a prime suspect, and it was hypothesized that nickel — like mercury — might appear in the hair of those poisoned by it. But Professors Lee Grodzins of M.I.T. and Paul Horowitz of Harvard found no abnormalities. They lacked a "control" — a hair sample from a known victim of nickel carbonyl poisoning.



From 14 buildings scattered through the M.I.T. neighborhood in Cambridge, the Charles Stark Draper Laboratory, Inc., has now moved into a 450,000-square-foot office-laboratory complex in Technology Square (above). It's a far cry from the "broom-closet" in which Professor Draper used to keep his papers and "second-hand-equipment" in the Laboratory's early years, but Dr. Draper (left, top) still has a key, a symbolic one presented to him at dedication ceremonies by Albert G. Hill, former M.I.T. Vice President for Research who is now Chairman of the C.S.D.L. (Photos courtesy of C.S.D.L.)

Beesley, Gendron Associates, Inc.

Management Consultants
and
Industrial Managers

George Beesley '39
Richard P. Gendron

441 Statler Office Building
Boston, Mass. 02116
Telephone: (617) 423-3632

Brewer Engineering Laboratories Inc.

Consulting Engineers
Experimental Stress Analysis,
Theoretical Stress Analysis,
Vibration Testing and Analysis,
Specialized Electro-Mechanical
Load Cells and Systems, Structural
Model Testing and Fabrication,
Strain Gage Conditioning and
Monitoring Equipment.
Stanley A. Wulf '65
G.A. Brewer '38,
Marion, Massachusetts 02738
(617) 748-0103

Capitol Engineering Corporation

Consulting Civil Engineers

Robert E. Smith '41,
Edward W. Boggs '56

Dillsburg, Pennsylvania 17019

Charles Nelson Debes Associates, Inc.

Engineers and Consultants

Structural, Electrical, Mechanical,
Acoustical, Industrial, Commercial
and Municipal Projects

C.N. Debes '35

915 East State Street
Rockford, Illinois

Uniting "the Search for Beauty and the Search for Truth"

While members of the Council for the Arts at M.I.T. were in Cambridge last fall to dedicate the new Henry Moore sculpture (see right), they took time — too — to honor their first Chairman, Paul Tishman, '24. He received the 1976 Eugene McDermott Award, presented annually for "major contributions to the arts as a means of human fulfillment."

Mr. Tishman, before retirement a major builder and contractor in New York City, has an important collection of African art, and his contributions to the arts at M.I.T. and elsewhere are well known. The citation for his McDermott Award paid tribute to his championship of "the idea that the search for beauty can be one with the search for truth."

The Council for the Arts at M.I.T., of which Mr. Tishman was charter Chairman, works to help the Institute provide students with meaningful experience in the arts and to acquire art for the campus.

A Confident Financial Report Shows Income Gaining on Growing Expenses

M.I.T. operating expenses in 1975-76 were $269.25 million; that's up 9 per cent from the $247.44 million in 1974-75.

Total operating revenues and funds used to meet those expenses in 1975-76 were $262.75 million, leaving $6.5 million from unrestricted revenues and funds needed to bring operations into balance.

Available revenues and funds were $238.4 million in 1974-75, leaving $9 million needed to balance operations. Thus there was a "substantial improvement in results in 1975-76," say Stuart H. Cowen, Vice President for Financial Operations, and Glenn P. Strehle, '58, Treasurer, in their annual report to the Corporation last fall.

The $6.5 million needed in 1975-76 to balance expenses and revenues came from five sources:

- ☐ Current allowances for the use of facilities by sponsored research programs, $1.2 million.
- ☐ Patent revenues, $457,000.
- ☐ Unrestricted gifts, grants, and bequests, including contributions to the Leadership Campaign, $2.216 million.
- ☐ Uncommitted fund balances, $1.2 million.
- ☐ Withdrawals of capital funds functioning as endowment, $1.4 million.

The last figure — $1.4 million taken from funds which would otherwise have been income-producing capital — compares with $2.6 million required from such funds in 1974-75; and that reduction is a principal reason for Messrs. Cowen's and Strehle's confidence in M.I.T.'s current financial situation. "The Institute has used relatively little capital during the last few years of extreme financial pressure in relation to many other colleges and universities," they told *Tech Talk*. "The results during the past year support optimism . . . for continued success in controlling expenses and in the development of growing financial resources."

In their annual report to the Corporation, President Jerome B. Wiesner and Chancellor Paul E. Gray, '54, forecast a further reduction in the demand for capital funds during the current 1976-77 year, and they proposed that the operating budget "will be at least in balance in the year that begins in July, 1977."

From then on, two goals will be uppermost, said Drs. Wiesner and Gray:

- ☐ Unrestricted current gifts must become available, at least in part, for capital investment, new endowment, and new programs, instead of being fully absorbed in the support of current operations.
- ☐ Rates of growth of expenses and revenues must be balanced "so that the financial state of the Institute is reasonably stable."

Crucial Role for the Leadership Campaign

A key to fulfilling these goals is success of the current $225 million Leadership Campaign. Gifts, grants, and bequests in 1975-76 were $22.4 million, up from $20.3 million in 1974-75 and more than in any of the previous five years. Gifts for endowment reached the highest level in eight years.

Continued growth in support from the Leadership Campaign is necessary "if the financial resources are to keep pace with either the inflation in operating costs or the continued growth in real demand for the continued research and teaching services provided by the Institute," Messrs. Cowen and Strehle told *Tech Talk*.

(On average, the prices colleges and universities in the U.S. paid for their goods and services rose 6.6 per cent in 1975-76, according to the Higher Education Price Index compiled by the National Institute for Education, a federal agency.

The book value of M.I.T.'s invested funds was $349.6 million on June 30, 1976, compared to $344.9 million on the same date in 1975. The increase resulted primarily from gifts under the Leadership Campaign to increase endowment for professorships and scholarships. The market value of M.I.T.'s investments was $401 million on June 30, 1976, compared with $376 million the year before. Investment income was just under $19 million.

The Fiesta Moves to the Yucatan

For 1977, the annual M.I.T. Fiesta in Mexico has a new site — and a new format. Guests will gather in Merida, Yucatan, on Thursday, March 17, and for the next three days will enjoy a whirlwind of social and archaeological events — the latter including visits to Uxmael and Chichen-itza. Headquarters will be in the Hotel El Castellano, Merida, and a post-Fiesta tour to the Yucatan Caribbean coast is planned.

Masaru Turu Kayaba, '58, is Program Chairman for the M.I.T. Club of Mexico, and further details are available from Joseph J. Martori or Nancy Russell in the M.I.T. Alumni Association — (617) 253-4876.

Chrysler Corp. is the newest member of M.I.T.'s Industrial Liaison Program, the Institute's effort to share its research with industry and to bring industrial problems into its classrooms and laboratories. To celebrate the new association, three Chrysler officials posed with Howard W. Johnson, Chairman of the M.I.T. Corporation (second from left): Thomas F. Morrow, '35, just retired from his post as Vice President — International Programs; Richard A. Vining, Vice President — Engineering and Product Development; and Sidney D. Jeffe (right), Vice President — Engineering. Chrysler's enrollment brought to 135 the number of companies who hold I.L.P. membership.

Are the gracious, spiralling stairways built into many of their Back Bay houses about to become a source of embarrassment to M.I.T. fraternities? It's possible; such stairwells are outlawed by a Boston safety code requiring enclosed stairways and two exits from each floor, which went into effect in 1975. The eventual alternatives are to enclose stairwells or install sprinklers to create a "water curtain" in case of fire.

Manson Benedict, Ph.D. '35, Institute Professor, Emeritus, who was the first Head of the Department of Nuclear Engineering, received a 1975 National Medal of Science from President Gerald R. Ford at the White House on October 18. He was honored for "inspired and ingenious leadership in the development of gaseous diffusion plants for uranium isotope separation, and for his role in creating the discipline of nuclear engineering." (Photo: Wide World)

J. H. Clausen, Ph.D.

CONSULTING IN CHEMICAL TECHNOLOGY

Environmental Analysis and Monitoring,
Feasibility and Impact Studies,
Process and Product Evaluation,
Product Safety, Occupational Health,
Industrial Hygiene, O.S.H.A.,
Legal Technical Assistance,
Complete Laboratory Services.

P.O. BOX 203, LEXINGTON, MASS., 02173
(617) 646-0220

Fay, Spofford & Thorndike, Inc.

Engineering for Government and Industry

Ralph W. Horne '10, Howard J. Williams '20, William L. Hyland '22, Edward C. Keane '22, Charles V. Dolan '31, William J. Hallahan '32, Fozi M. Cahaly '33, George M. Reece '35, Bruce Campbell '49, Paul J. Berger '50, Max D. Sorota '50, Rodney P. Plourde '68

One Beacon Street, Boston, Mass. 02108

Haley & Aldrich, Inc.

Consulting Geotechnical Engineers and Geologists

Soil and Rock Mechanics
Engineering Geology
Engineering Geophysics
Foundation Engineering
Terrain Evaluation

Harl P. Aldrich, Jr. '47
Martin C. Murphy '51
Edward B. Kinner '67
John P. Dugan '68
Douglas G. Gifford '71
Joseph J. Rixner '68

238 Main Street, Cambridge,
Mass. 02142 617-492-6460

H. H. Hawkins & Sons Co.

building contractors

Steven H. Hawkins, '57

188 Whiting Street
Hingham, Mass. 02043
(617) 244-8111

Paul E. Dutelle & Company, Inc.

Roofers and
Metal Craftsmen

153 Pearl Street
Newton, Mass.

Lord Electric Company Inc.

Electrical contractors
to the nation since 1895

Headquarters:
45 Rockefeller Plaza
New York, N.Y., 10020

Offices in 16 principal
cities throughout the U.S.
and Puerto Rico

Boston Office:
4080 Mystic Valley Parkway
Medford, Mass., 02155
(617) 396-9110

Norcross Corporation

Specialists in
Viscosity Process Control

255 Newtonville Ave.
Newton, Ma 02160
(617) 969-7020

Ten Beavers, Five Citations

Who were the shining examples of service to M.I.T. among alumni and their organizations in 1975-76?

These ten alumni who received Bronze Beaver Awards at the Alumni Officers Conference on September 18:

Harl P. Aldrich, '47, President of Haley and Aldrich, Inc., Cambridge, Mass.

Henry Avery, '41, Vice President of USS Chemicals, Pittsburgh.

Homer A. Burnell, '28, of Chicago, Ill.

Edward J. Hanley, '48, of Edward Hanley and Co., Denver.

Charles W. Hargens, '41, Institute Fellow of the Franklin Institute, Philadelphia.

Joe F. Moore, '52, President of Bonner and Moore Associates, Inc., Houston.

Franklin E. Penn, '40, President and Chief Executive Officer of Velcro Industries, New York.

David A. Shepard, '26, of Greenwich, Conn.

Paul P. Shepherd, '53, of Milton Meyer and Co., San Francisco.

Harold H. Strauss, '38, consulting engineer of Santa Monica, Calif.

And these five alumni organizations that received Presidential Citations:

The M.I.T. Club of Rochester, N.Y., for integrated Club activities, an active corps of Educational Counselors, and "one of the most highly supported" Alumni Fund programs in the U.S.

The M.I.T. Club of Washington, D.C., for the high quality of its regular activities and of its 1976 regional conference.

The M.I.T. Club of Northern California (San Francisco), for its "success in creating an integrated community of 2,600 alumni" and in sponsoring a 1976 regional conference.

The M.I.T. Club of Mexico City, for its hospitality to visiting alumni through a 28-year series of mid-winter Fiestas.

The Class of 1951, for "an unsurpassed record of support of the Institute's goals."

The Bronze Beaver is the highest honor the Alumni Association can bestow on an individual alumnus, and the Presidential Citation is given by the Board of Directors for equally meritorious services by an organization. Edward O. Vetter, '42, President of the Alumni Association who is now serving as Undersecretary of Commerce, made the awards.

Individuals Noteworthy

M.I.T. Administration

Alumni

Rosemary Carpenter, who's had management experience in several M.I.T departments and laboratories, is now Administrative Assistant to Richard A. Knight, '47, Secretary of the Alumni Association. Ms. Carpenter's first task is staff support for M.I.T. clubs in the U.S. and overseas. . . . **Charles A. Hatvany,** '72, has brought his expertise in systems management from the Bank of America (San Francisco) to Cambridge, where he is now Senior Systems Analyst for the Association. . . . **Nancy Russell** is now Administrative Assistant to Joseph J. Martori, Director for Alumni Services.

Industrial Liaison

Shirley M. Picardi, Ph.D. '76, became Industrial Liason Officer upon completion of her doctorate in food science and technology, for which she developed a minicourse in food chemistry and nutrition for high school students.

Information Processing Services

Weston J. Burner, who has been Assistant Director of M.I.T.'s Information Processing Center since 1969 and Director of the Office of Administrative Information Systems since 1975, has moved up to become Director of I.P.C., succeeding **Robert H. Scott,** '64, who left the Institute during the summer. And **Joseph R. Steinberg,** formerly I.P.C.'s Assistant Director, has advanced to be Associate Director. Mr. Burner will focus on long-range planning and administrative computing requirements, Mr. Steinberg on academic and research computing requirements.

M.I.T. Press

Formerly with Cambridge University Press and American Book Co., **Colin Jones** joined the M.I.T. Press this summer as Acquisitions Editor in Architecture and Planning.

Medical

Dr. **Melvin H. Rodman,** who has been Associate Medical Director since 1970 and became Acting Director upon the death last spring of Dr. **Albert O. Seeler,** is now Medical Director. Dr. Rodman, whose specialty is thoracic medicine, has been at M.I.T. since 1959; he studied at Harvard College and Boston University Medical School (M.D. 1945).

Personnel

Claudia R. Liebesney, formerly Assistant Director of Personnel Services, has been named Director; **James J. Culliton** has returned to full-time work as Assistant to John M. Wynne, Vice President for Administration and Personnel.

Kudos: Honors, Awards, Citations

Anthony W. Slusarz, '65, Senior Actuarial Assistant at Aetna Life and Casualty, was designated a Fellow of the Society of Actuaries . . . **Walter H. Stockmayer,** '35, Albert W. Smith Professor of Chemistry at Dartmouth College, was elected an Honorary Fellow of Jesus College, Oxford Univeristy.

To **Walter A. Rosenblith,** M.I.T. Provost, Institute Professor and Professor of Communications Biophysics in the Department of Electrical Engineering and Computer Science, honorary doctor of science degrees from the University of Pennsylvania and the Federal University of Rio de Janeiro . . . to **John F. Collins,** Consulting Professor of Urban Affairs at the Sloan School, an honorary doctor of laws degree from Stonehill College, Easton, Mass. . . . to **Sheila Widnall,** '60, Professor of Aeronautics and Astronautics at M.I.T., an honorary doctor of science degree from New England College, Henniker, N.H. . . . to **Frank S. Jones,** Professor of Urban Affairs at M.I.T., an honorary doctor of humane letters from Trinity College, Hartford, Conn. . . . to **Carroll L. Wilson,** '32, Professor in Problems of Contemporary Technology at the Sloan School and Professor of Electrical Engineering, an honorary doctorate in engineering from the Worcester Polytechnic Institute . . . to the late **Minor White,** Professor Emeritus of Photography and Senior Lecturer in Architecture at M.I.T., an honorary doctor of fine arts from the San Francisco Art Institute.

To **Robert R. Shrock,** Professor Emeritus of Geology at M.I.T., the Boston College Presidential Bicentennial Award . . . to **Stephen J. Kline,** Sc.D. '52, Professor of Mechanical Engineering at Stanford University, the Fluids Engineering Award of American Society of Mechanical Engineers . . . to Lt. Col. **Ernest D. Strait,** '55, the Meritorious Service Medal at Hickam A.F.B., Hawaii . . . to **John M. Cowley,** Ph.D. '49, Professor of Physics at Arizona State University, the Bertram Eugene Warren Diffraction Physics Award . . . to **Malcolm Hill,** '73, a graduate student in earth sciences at the University of California, Santa Cruz, the Aaron and Elizabeth Waters Student Research Award . . . to **Herman A. Bruson,** '23, the designation of Chemical Pioneer by the American Institute of Chemists . . . to **Frederick T. Rall,** '50, Technical Director of the U.S. Air Force Aeronautical Systems Division, the Air Breathing Propulsion Award of the American Institute of Aeronautics and Astronautics . . . to **J. Robert Schrieffer,** '53, Professor of Physics at the University of Pennsylvania and Nobel Laureate, the 1976 John Ericsson Medal of the American Society of Swedish Engineers . . . to **Clinton O. Chichester,** '49, Vice President for Science of the Nutrition Foundation and Professor of Food and Resource Chemistry at the University of Rhode Island, the 1976 International Award of the Institute of Food Technologists . . . to **Leonard Coris,** '61, Wayland affiliate of the Boston general agency of the National Life Insurance Co. of Vermont, membership in the company's 1976 President's Club.

To **Manson Benedict,** Ph.D. '35, Institute Professor Emeritus of Nuclear Engineering at M.I.T., and **Frederick E. Terman,** '24, Vice President and Provost Emeritus at Stanford University, the Medal of Science, the nation's highest award for scientific achievement . . . to **Bernard Vonnegut,** '36, Senior Scientist at the Atmospheric Sciences Research Center and Professor in the Department of Atmospheric Science at S.U.N.Y. at Albany, the Outstanding Contribution to the Advance of Applied Meteorology Award of the American Meteorological Society . . . to **Robert E. Dickenson,** Ph.D. '66, Leader of the Climate Project at the National Center for Atmospheric Research in Boulder, Colo., a 1976 Editor's Award of the American Meteorological Society for his contributions to the *Journal of the Atmospheric Sciences* . . . to **Joseph C. Boltinghouse,** '43 staff member of Rockwell International's Minuteman Guidance and Control Equipment Department, one of ten chosen for Rockwell International's Engineer of the Year Awards. . . . to **Walter J. Smith,** '28, retired professional engineer, honorary membership in the Air Pollution Control Association.

To **Thomas Malone,** Sc.D. '46, Director of the Holcomb Research Institute of Butler University, the Guy E. March Medal for outstanding achievement by an alumnus of South Dakota State School of Mines . . . to **Robert R. Shrock,** Emeritus Professor of Geology and former head of the Department of Earth and Planetary Sciences at M.I.T., the William H. Twenhofel Medal of the Society of Economic Paleontologists and Mineralogists . . . to **Lawrence G. Roberts,** '59, President of Telenet Communications Corp., Washington, D.C., the 1976 Harry Goode Memorial Award of the American Federation of Information Processing Societies, Inc. . . . to **John S. Reynolds,** M. Arch., '67, Associate Professor of Archi-

M. H. Rodman

Syska & Hennessy, Inc.

Engineers

Mechanical-Electrical-Sanitary
Elevator & Materials Handling

Specialty Divisions:
S&H Information Systems, Inc.
Engineering Management Division
Lighting Design Workshop
Site Planning-Automation

John F. Hennessy, Jr. '51

110 West 50th Street
New York, N.Y. 10020

1720 Eye Street, N.W.
Washington, D.C. 20005

1900 Avenue of the Stars
Century City
Los Angeles, California 90067

4, Rue de Penthievre
75008 Paris

Jordan Road, Boulevard Saba No. 40
Tehran, Iran

TAD Technical Services Corp.

Contract Engineering Services

Offices in:

California	New York
Illinois	Pennsylvania
Maryland	Texas
Massachusetts	Virginia

Home Office:
639 Massachusetts Avenue
Cambridge, Massachusetts 02139
Telephone: (617) 868-1650

Alexander Kusko, Inc.

Research, Development and Engineering Services in the Electrical Engineering Field

Specialties:
Electric power systems,
Electric transportation equipment,
Electric machinery and magnetics,
Solid-state motor drives, rectifiers, inverters,
Feedback control systems,
Computer applications and modeling,
Evaluation, investigation, patents.

Alexander Kusko '44
Thorleif Knutrud, Jr. '54
Wendell E. Phillips, Jr. '42

161 Highland Avenue
Needham Heights, Mass. 02194
(617) 444-1381

Mueser, Rutledge, Wentworth & Johnston

Consulting Engineers

Foundations for Buildings, Bridges and Dams-Tunnels-Bulkheads-Marine Structures-Soil Studies and Tests-Reports, Design and Supervision

William H. Mueser '22,
Philip C. Rutledge '33
James P. Gould '46

415 Madison Avenue
New York, New York 10017

Polysciences, Inc.

Research, development, and consultation in the fields of polymers, monomers, life sciences, medical plastics, custom chemical synthesis, dyes, stains, diagnostics, etc.

B. David Halpern, '43

Paul Valley Industrial Park
Warrington, Pennsylvania
(North of Philadelphia)
(215) 343-6484

Stearns & Wheler

Civil and Sanitary Engineers
Consulting Engineers

Sewerage Drainage and Flood Control, Water Supply and Distribution, Water and Waste Treatment, Municipal Engineering, Refuse Disposal,

W.O. Lynch '47, S.G. Brisbin, '50
A.G. Wheler '51, D.E. Schwinn '59

10 Albany Street, Cazenovia, New York 13035 (315) 655-8161

tecture at the University of Oregon, that University's 1976 Ersted Award for Distinguished Teaching . . . to **Richard C. Lord,** Professor of Chemistry and Director of the Spectroscopy Laboratory at M.I.T., the Ellis R. Lippincott Medal of the Coblentz Society, the Optical Society of America, and the Society for Applied Spectroscopy.

Victor F. Weisskopf, Institute Professor Emeritus and Professor of Physics Emeritus at M.I.T., and **Henry M. Stommel,** Professor of Oceanography at M.I.T., elected foreign members of the Soviet Academy of Sciences . . . to **Carl I. Wunsch,** '62, Professor of Physical Oceanography in the Department of Earth and Planetary Sciences at M.I.T., the 1975 Founders' Prize of the Texas Instruments Foundation . . . to **Gordon S. Brown,** Institute Professor Emeritus at M.I.T., the 1976 Robert Fletcher Award at the Thayer School of Engineering at Dartmouth College.

To **Jerome J. Tiemann,** '53, physicist at General Electric Research and Development Center, G.E.'s Coolidge Fellowship Award . . . to **Donald W. Male,** SL '58, minister of the Tullahoma Unitarian Fellowship, the Florence Conwell Prize for outstanding work in preaching of the Divinity School at Vanderbilt University . . . Sir **William Rede Hawthorne,** Sc.D. '39, Visiting Professor of Engineering at M.I.T., to a Foreign Associate of the National Academy of Engineering . . . to **William J. Sherry,** '21, independent oil operator and broker of Tulsa, Okla., the Distinguished Service to Oil Industry Pioneers' award of the International Petroleum Exposition.

Athelstan Spilhaus, S.M. '43, Special Assistant to the Administrator of the National Oceanic and Atmospheric Administration, to a Phi Beta Kappa Visiting Scholar for 1976-1977 . . . Three professors in the Department of Physics at M.I.T. elected to membership in the American Academy of Arts and Sciences: **Herbert S. Bridge,** Ph.D. '50, also Associate Director of the Center for Space Research at M.I.T.; **Bruno Coppi,** and **Kerson Huang,** '50. Elected to Fellows of the American Nuclear Society: **Robert J. Teitel,** Sc.D. '48, Principal Scientist at KMS Fusion, Inc., Ann Arbor, Mich.; and **Lester Kornblith,** '38, member of the Atomic Safety and Licensing Board Panel of the U.S. Nuclear Regulatory Commission . . . **F. B. Stern, Jr.,** S.M. '40, Field Engineer for Magnaflux Corp., New York City, to Fellow of the Society for Experimental Stress Analysis. Honorary degrees were awarded at 1976 commencement to: **David Baltimore,** American Cancer Society Professor in Microbiology at M.I.T., from Swarthmore College . . . **Nathan Cohn,** '27, retired Executive Vice President for Research and Development at Leeds & Northrup Co., from Rensselaer Polytechnic Institute . . . **Richard T. Lyons,** '17, independent oil operator and investor, from the University of St. Thomas . . . **Robert L. Sinsheimer,** '41, Chairman of the Division of Biology at California Institute of Technology, from Northwestern University . . . **William J. Weisz,** '48, President and Chief Operating Officer of Motorola, Inc., from St. Ambrose College . . . and **James S. McDonnell,** S.M. '25, Chairman of the Board and Chairman of the Executive and Finance Committees of McDonnell Douglas Corp., from Clarkson College.

Counselors: Officers, Directors, Advisors

James A. Drobile, S.M. '50, patent attorney and partner in the Philadelphia law firm of Schnader, Harrison, Segal and Lewis, has been elected a Trustee of Villanova University . . . **Robert M. White,** Sc.D. '50, Administrator of the National Oceanic and Atmospheric Administration, to a Counselor of the American Meteorological Society . . . **Richard P. Simmons,** '53, President of the Specialty Metals Group of the Allegheny Ludlum Industries, Inc., and of Allegheny Ludlum Steel Corp., to the Board of Directors of Pittsburgh National Corp. . . . **John T. McKenna, Jr.,** '50, Vice President of Operations for Boston Gas Co., to their Board of Directors . . . **Paul E. Gray,** '54, Chancellor of M.I.T., to a four-year term as Chairman of the Board of Trustees of Wheaton College.

Charles W. Ellis, '51, Vice President and Assistant General Manager of Boeing Vertol Co. in Philadelphia, to President of the American Helicopter Society . . . **Stephen J. Jatras** '52, President of Telex Corp., Tulsa, Okla., to the Board of Trustees of Carnegie-Mellon University . . . **R. Stanley Bair,** '50, owner of the architectural firm R. S. Bair Associates of Houston, to a Vice President of The Construction Specifications Institute . . . **Peter Samton,** '57, a partner of the architectural firm of Gruzen & Partners of New York City, to First Vice President and President-Elect of the New York Chapter of the American Institute of Architects.

Charles A. Zraket, S.M. '63, Senior Vice President for Technical Operations at MITRE Corp., to Vice Chairman of Virginia Governor's Council on Transportation for a two-year term . . . **Vincent A. Fulmer,** S.M. '53, Secretary of the Institute at M.I.T., to Chairman of the Board of Trustees of Suffolk University . . . **Gordon Brownell,** Ph.D. '50, Professor of Nuclear Engineering at M.I.T., to the Board of Directors of the American Nuclear Society . . . **Jerome B. Wiesner,** President of M.I.T., and **Carroll L. Wilson,** '32, Mitsui Professor of Management at M.I.T., to Trustees of the Woods Hole Oceanographic Institution . . . **W. H. Krome George,** '40, President and Chief Executive Officer of the Aluminum Co. of America, and **Brian E. Tucholke,** Ph.D. '73, Research Associate at Columbia University's Lamont Doherty Geological Observatory, to Members of the Corporation of Woods Hole Oceanographic Institution.

M.I.T. faculty elected to membership terms in the Institute of Medicine: **Boris Magasanik,** Professor and Head of the Department of Biology; **Irving M. London,** Di-

rector of the Harvard-M.I.T. Program in Health Sciences and Technology; **Robert W. Mann,** '50, Professor of Biomedical Engineering; and **Walter A. Rosenblith,** Institute Professor and Provost.

Seppo J. Halme, Ph.D. '70, Professor of Electrical Engineering at Helsinki University of Technology, to President of The Society of Electronics Engineers in Finland and Member of the Academy of Engineering Sciences in Finland . . . **Hartley Rogers, Jr.,** Associate Provost and Chairman of the M.I.T. Press Editorial Board, to membership on Governor Michael S. Dukakis' Judicial Nominating Commission . . . **William Eykamp,** Ph.D. '65, Vice President and General Manager of the Operations Division of Abcor, Inc., to corporate member of Morgan Memorial Goodwill Industries of Boston, a non-profit rehabilitation agency . . . **David L. Rosenbloom,** Ph.D. '70, from Acting Executive Director to Commissioner of Boston's Health and Hospitals Department . . . **Richard P. Kotelly,** '56, to Deputy Director of the Water Program Division of the New England Regional Office of the U.S. Environmental Protection Agency.

Michael S. Baram, an attorney and Associate Professor in Civil Engineering at M.I.T., to member of the Council on Science, Technology and Law of the American Bar Association . . . **Alexander Rich,** Professor of Biology at M.I.T., to member of the National Science Board, governing body of the National Science Foundation . . . **Thomas J. Regan,** S.M. '68, to Director of Public Works, Howard County, Md. . . . **Herbert D. Friedman,** Ph.D. '68, an Associate in the Boston firm of Mahoney, Hawkes and Goldings, to Chairman of the Committee on Mental Health of the Massachusetts Bar Association . . . **Arthur B. Metzner,** Ph.D. '51, Professor and Chairperson of the Department of Chemical Engineering at the University of Delaware, to member of the Corporation Visiting Committee of the Chemical Engineering Department at M.I.T. . . . **Barry M. Bloom,** '48, President of Pfizer Central Research, to the Advisory Panel on Applications of Science and Technology of the U.S. Congress Office of Technology Assessment.

Appointments: Rising in the World of Business

Llewellyn S. Bolton III, S.M. '60, Vice President of Zaldastani Assoc., Inc., structural engineers, of Boston . . . **John W. Brackett,** '59, President, Director and Chief Executive Officer of SofTech, Inc., Waltham, Mass. . . . **Charles E. Leonard III,** '58, Vice President of William E. Hill and Co., Inc. . . . **Theodore A. Burtis,** M.S. '63, President and Chief Operating Officer of Sun Co., Inc. . . . **Amos Levin,** Ph.D. '69, Controller of Eastern Gas and Fuel Associates, Boston.

Stephen R. Helpern, '62, Director of Acquisitions of Consolidated Foods Corp., Chicago . . . **Rodger L. Foltz,** '56, Senior Research Leader at Battelle's Columbus Laboratories . . . **I. S. Servi,** Sc.D. '51, Director of Product Development at Ledgemont Laboratory, the corporate technical center of Kennecott Copper Corp. in Lexington, Mass. . . . **Jon M. Heuss,** '62, Assistant Head of the Department of Environmental Science at the General Motors Research Laboratories . . . **Bernard J. Patnode,** '56, Director of Operations at Deft, Inc., Los Angeles, Calif. . . . **Robert B. Hedges,** S.M. '55, General Manager of Combustion Engineering Marine Power Systems, Windsor, Conn.

Karl Moller, '66, Assistant Secretary and Actuary for the Commercial Lines Actuarial Unit of The Home Insurance Co., Boston. . . . **George Vrablik,** '58, Chief Engineer of Ring Saws, Inc., Waltham, Mass. . . . **Martin Weinstein,** Sc.D. '61, President of Turbine Support, a division of Chromalloy Metal Tectonics in San Antonio, Tex. . . . **George A. Snyder,** '59, Manager of New Products for Dravo Lime Co., a subsidiary of Dravo Corp. . . . **William A. Dreier,** '58, Judge of the Union County Court, Elizabeth, N.J. . . . **Albert Sanchez,** S.M. '64, Director of Operations of Hybrid Circuits for Analog Devices, Wilmington, Mass.

Obituaries

Santo A. Benichasa, 1939-1976

Santo A. (Sam) Benichasa, Staff Engineer at the Charles S. Draper Laboratory who contributed to many student and staff activities at M.I.T., died suddenly on September 21 after running on the track at Briggs Field.

There was nothing conventional about Mr. Benichasa's interests, and nothing passive about his approach to them. He was Commissioner of the M.I.T. Summer Softball League, which under his leadership grew to include more than 750 participants; he organized and taught a wide variety of projects during the Independent Activities Period; and he taught folk music at the Cambridge Center for Adult Education. A memorial service in the M.I.T. Chapel on October 5 paid special tribute to Mr. Benichasa's unconventional interests: there was classical guitar, organ, and chamber music, and at the end a 15-piece Dixieland jazz band leading the audience equipped with kazoos and spoons. "And it's just the way Sam would have wanted it," said a member of the arrangements committee.

Thomas P. McLennan, 1924-1976

Thomas P. McLennan, who had coached M.I.T.'s highly successful pistol teams for ten years, died September 1 following surgery at Choate Memorial Hospital, Woburn. He was 52.

Mr. McLennan came to M.I.T. in 1965 following more than 20 years in the U.S. Air Force; he had taught marksmanship to several thousand students and staff, and during his tenure the M.I.T. pistol team was twice National Pistol Champions; seven of his students won All-American status.

technology services inc.

technical and industrial marketing consultants

Michael K. Bonner '49

14 Vanderventer Avenue
Port Washington, N. Y. 11050
(516) 767-1440

Saxton W. Fletcher, 1895-1976

Saxton W. Fletcher, '18, former Vice Chairman of the Board of Midland-Ross Corp., died on August 13 at his home in Greenfield, N.H. He was 81.

Mr. Fletcher was Vice President of the Alumni Association from 1956 to 1958, and he was prominent in alumni activities for a number of years. After studying air conditioning, heating, and ventilation in the Department of Mechanical Engineering at M.I.T., Mr. Fletcher joined the J. O. Ross Engineering Corp., New York, in 1923; he rose to become its President from 1944 to 1965, when it was merged with Midland Steel Co.

Deceased

Howard T. Chandler, '01; July 6, 1976
Frank H. Davis, '04; May 1, 1976; 961 Burns Ave., Detroit, Mich.
Robert M. Phinney, '04; September 1, 1976; 4417 Evergreen Dr., Woodbridge, Va.
Herbert S. Bailey, '05; August 27, 1976; 1122 North Euclid Ave., Ontario, Calif.
Roland H. Willcomb, '07; August 24, 1976; Rt. 1, Box 397, Silverdale, Wash.
Gordon G. Howie, '13; September 13, 1976; Apt. B-13, 1221 Drew St., Clearwater, Fla.
Gerald W. Blakeley, '14; September 20, 1976; 114 Pleasant St., Arlington, Mass.
Walter H. Leathers, '14; June 25, 1975; 182 North St., Hingham, Mass.
Fay W. Williams, '14; June 24, 1976; 70 Chestnut St., Springfield, Mass.
Charles A. Abels, '17; August 4, 1976; Greenbriar Terrace Health Care, 55 Harris Rd., Nashua, N.H.
Charles W. Dow, '18; July 3, 1976; 12 Phillips Ave., Rockport, Mass.
Harry Cikins, '19; July, 1976; 41 Kirkwood Rd., Brighton, Mass.
Edward F. Deacon, '19; June 18, 1976; 2 Painted Bunting, Hilton Head Island, S.C.
Charles E. Mendinhall, '21; July 6, 1976
Charles C. Morss, '21; September 10, 1976; 91 Ledyard Rd., West Hartford, Conn.
Osborne A. Browne, '22; June 22, 1976; Box 155, Colrain, Mass.
Herbert C. Ham, '22; September 8, 1976; c/o Mrs. H. H. Bard, 87 Commonwealth Ave., Pittsfield, Mass.
Charles M. Welbing, '22; November 24, 1975; Main St., North Bennington, Vt.
Lawrence W. Jordan, '23; August 5, 1976; 12 Copley Rd., Larchmont, N.Y.
Francis M. Corliss, '25; August, 1976; Apt. 8, 750 Coleman Ave., Menlo Park, Calif.
Stephen Y. Gilligan, '25; September 16, 1976
Horace E. Weihmiller, '25; July 10, 1976; 8903 Hempstead Ave., Bethesda, Md.
Henry G. Schmidt, '27; June 16, 1976; 2876 Weybridge Rd., Cleveland, Ohio
Donald M. McAndrew, '30; July 15, 1976; 4987 Sweetbriar St., Baton Rouge, La.
Louis C. Rubin, '30; June 21, 1976; 5532 Ladybird Ln., La Jolla, Calif.
Ralph E. Scott, '30; July 28, 1976; 5702 W. Ridgewood Dr., Parma, Ohio
Stanley C. Wells, '30; July 7, 1976; 435 Antlers Dr., Rochester, N.Y.
Rex I. Heinlein, '31; August 26, 1976; 860 Seale Ave., Palo Alto, Calif.
Raymond W. Miller, '31; July 10, 1976; R1 Riverview Dr., Chatham, Mass.
Robert K. Wilson, '31; September 16, 1976; 31 Cove Rd., West Yarmouth, Mass.
Irving I. Schell, '32; July, 1976; 82 Pine Grove, Newton Lower Falls, Mass.
Gordon Glover, '34; June 15, 1976; 71 Moseley Terr., Glastonbury, Conn.
William W. Ragland, '34; July 30, 1976; 182 Corte Anita, Greenbrae, Calif.
Donald E. Kerr, '37; May, 1975; 3938 Cloverhill Rd., Baltimore, Md.
S. Joseph Tankoos, Jr., '43; September 20, 1976
Bernard J. Haverback, '46; July 28, 1976; 4855 Radford Ave., North Hollywood, Calif.
Er Chun Ho, '48; July 13, 1975; 1807 Commodore Rd., Newport Beach, Calif.
Harold E. Keene, Jr., '49; August 21, 1976; 32 Marlowe Dr., Nashua, N.H.
Henry B. DuPont, '55; September 12, 1976; 303 Hulls Farm Rd., Southport, Conn.

KULITE

METALLURGY

Tungsten, molybdenum, cobalt, special alloys — fabrications. "HI-DENS" tungsten alloys — for counterweights and shielding.

SOLID STATE SENSORS

Semiconductor strain gages, integral silicon force sensors and temperature sensors for measurement and control applications.

Anthony D. Kurtz, 1951
Ronald A. Kurtz, 1954

KULITE

(Kulite Semiconductor Products, Inc., Kulite Tungsten Corporation)
1030 Hoyt Avenue, Ridgefield, N. J.

albert

PIPE • VALVES • FITTINGS
Steel / Yoloy / Aluminum
Plastic / Stainless / Alloy
PIPE FABRICATION From one coded pressure vessel to complete power plant pre-fabricated piping.
SPEED-LAY. Economical pipe system for oil-gathering, dewatering and chemical processing lines.
PIPE PILING & ACCESSORIES
Pipes & clamps for storage racks.

WRITE FOR FREE BROCHURE:
ALBERT PIPE SUPPLY CO., INC.
Manufacturers—Fabricators—Distributors
101 VARICK AVE., BROOKLYN, N. Y. 11237
Telephone: 212-497-4900
S.G. ALBERT '29 • A.E. ALBERT '56

Classes

01

Howard T. Chandler, of Weymouth, Mass., died July 6, 1976 at the age of 95. He graduated from M.I.T. with a degree in mechanical engineering and spent 20 years of his working career as superintendent of the Walter Baker Chocolate Co. of Milton, Mass. He is survived by a daughter, Priscilla T. Chandler of Hot Springs, Ark. — *S.F.*

04

We have two deaths to report this month. Lief Davis wrote that his father, **Frank H. Davis** of Historic Indian Village in Detroit, died May 1, 1976. After he was graduated from M.I.T., Mr. Davis began his career with the engineering department of the Chicago and Northwestern Railroad in Chicago and the Southern Pacific Lines. He later became a major building contractor in Detroit and the president of the Basin Oil Co., vice president of Kales-Kramer Investment Co.; and a director of Whitehead and Kales Steel Co., of River Rouge, and the Bethlehem Fabricators Steel Co. He was a member of the Independent Petroleum Association, the Engineering Society of Detroit and the Managers Association. In addition to his son, he is survived by a daughter, and two grandchildren.

Robert Morris Phinney, of Woodbridge, Va., died on September 1, 1976. After two years with the Swan Electric Co., of Boston, he moved into railroading and from 1907 to 1928 he worked for the Signal Department of the Chicago and Northwestern Railroad. In 1928, he joined the General Railway Signal Co. in Rochester, N.Y., where he lived until the death of his wife in 1973. There he pioneered in the development of signal and control techniques for railroads, which lead him to consulting assignments world-wide in railroad modernization. — *S.F.*

05

Herbert S. Bailey, of Ontario, Calif., died August 27, 1976. He was a retired manager of the Orange Products Division of Sunkist Growers, Inc., and had been active in the Rotary Club of Ontario, the American Chemical Society, and the Civil Service Commission.

He is survived by his son, Edgar Herbert Bailey of Redwood City, and his daughter, Mrs. Owen E. Moore of Ontario, eight grandchildren and five great-grandchildren. — *S.F.*

07

Roland Howard Willcomb, of Silverdale, Wash., died August 24, 1976. He was born in 1884 in Ipswich, Mass., and was a civil engineer with the Montana Highway Commission for many years before retiring in 1949. He is survived by his wife, Betty; four daughters, ten grandchildren and ten great-grandchildren. — *S.F.*

08

There are 36 living members of our class and we are missing present addresses for four of these classmates: **Huntley Child**, **Ludwig F. Hass**, **Frederick W. Lyle**, and **Roger C. Rice**. Anyone knowing of their whereabouts, please let us know.

Your secretary, **Joseph W. Wattles III** is moving from 26 Bullard Rd., Weston, to 600 Washington St., Wellesley, Mass. 02181

Frank H. Davis, '04

10

I regret to inform our classmates of the death of **Herman C. Schmidt** on March 24, 1976, in Richmond, Va. At M.I.T., Herman was a member of Hammer and Tong, the Southern Club and the Electrical Engineering Society. In the 1930s he founded the Power Equipment Co. in Richmond and remained active in that organization throuhout the rest of his business life. He maintained a great interest in Virginia Military Institute, where he was graduated before attending M.I.T. His survivors include his wife, Mary, two sisters and three grandchildren. We extend our sympathy to his widow and other relatives. — **John B. Babcock**, Secretary, 33 Richardson St., Portland, Maine 04103

12

Wallace Murray has been having a difficult time this summer. He wrote in late August that he had been living alone and had been taken ill in the night. He had to be rushed to the hospital, where he remained for 11 days. Not being able to care for himself, his son and daughter-in-law moved him to their lovely home on Sebago Lake. On July 30 it was necessary to re-enter the hospital where he remained until August 17, at which time he returned to Sebago Lake. Wally says he will "be delighted to see any classmates who may come to the Portland area." I am sure he would appreciate a card or note. His address at Sebago Lake is P.O. Box 17, Sebago Lake, Me. 04074. We sincerely hope that you are making good recovery progress, Wally, and will look forward to seeing you in June. . . . **Harold Brackett** writes that hurricane Belle just missed them at Limerick, Me. He has been over to see Wally Murray at Sebago Lake. As you may know, Harold and his niece, Eleanor, are avid fishers. Harold reports exploring the stream from Stinson Lake, in the White Mountain National Forest; he concludes it is "no good for fly fishing." They have tried Swift River again, no luck. Same for mackerel at Popham Beach; "poorest surf fishing in 20 years." They have been at Sourdnahunk Lake in Maine the last two weeks in September. For the last two years Eleanor has been tops on the totem pole, having caught the largest trout each year. — **Larry Cummings**, Secretary, RR 4, Connersville, Ind. 47331

13

Merry Christmas to you all.

We didn't get to the Alumni Officers Conference, but we understand the Class was represented by **Henry Glidden**, **Charlotte Sage**, and **Francis Achard**.

Not much news to report this month. Phil was in the hospital for ten days with an attack of ileitis, but is home now and gradually regaining his strength.

We regret to report the death of **Gordon G. Howie** on September 13. Gordon, 85, was retired Vice President and General Manager of Cambridge Gas Co. He died at Bruce Manor Nursing Home in Clearwater, Fla. He had moved to Florida in 1960 from Weston, Mass., and Drake Island, Maine. A native of Melrose, Gordon was graduated with a degree in civil engineering. He was past President of the New England Gas Associates and the Somerville Kiwanis Club, and Director of the Guild of New England in Boston, the American Gas Associates, Engineers Club of Boston, the New Commerce Society of North America, and the Regional Group of Industrial Relations. He also served on the Board of Directors of the Cambridge Gas Co., Cambridge City Bank and Trust Co., and the Cambridge and Somerville Chamber of Commerce. A former trustee of Fisher Junior College, he also was former President of the Cambridge Industrial Track Management Association and the Drake Island Improvement Association. He leaves two sons, Malcolm P., of Walton, N.J., and Dr. Donald I. Howie of St. Petersburg, Fla., a daughter, Laura C. Howie of Auburn, Mass., and three grandchildren.

As our expenditures have been small this past year, we have enough in our treasury to carry on and thus are not sending out "dues bills" this year. However, please send us news so that we will have some notes. — **George Philip Capen**, Secretary and Treasurer, **Rosalind R. Capen**, Assistant Secretary, Granite Point Rd., Biddeford, Maine 04005

14

The total of our gifts to the 1976 Alumni Fund was $26,089, more than that of any class senior to us;

and the percentage of contributing members was as good as that of any of those classes except one that has only two active members. Your class beggar respectfully hopes that we'll do even better by the 1977 Fund.

Last August **Roswell Barratt** welcomed me at his home in Southport, Conn., and we lunched at the Pequot Yacht Club. Ros has been practicing architecture ever since graduation, and is still not wholly retired. Among his successful projects was the conversion of a barn into the attractive and interesting house in which he's lived since 1956. Since the death of his wife, Hetty, last year Ros has been alone, but his son, Grant (M.I.T. '55) lives within easy driving distance, so Ros' three grandsons can often stay with him.

Gerald W. Blakeley died at the age of 88 on September 20, after a long illness, in a hospital in Arlington, the town in which he had lived for the past 13 years. He was born in Springdale, N.Y., was a member of the class of 1910 at Oberlin College, received his S.B. degree with us in Course II and was a member of Phi Beta Epsilon. After two years on the staff of the physics department at the Institute, Gerry joined Johns-Manville Corp., and was with that company for 38 years. After that he was chief planning engineer of the division of building construction of the Commonwealth of Massachusetts until his retirement in 1956. Gerry is survived by his wife, the former Mabel E. Roy, whom he married in 1918; a son, Gerald W. Blakeley, Jr.; a daughter, Mrs. Jean W. Whitman; seven grandchildren and four great-grandchildren.

Fay W. Williams died in a New Hampshire hospital on June 24 at the age of 84. He was born in Holyoke, was with us in all four years, and received his bachelor's degree in Course XI. After service in World War I, he became a construction superintendent with Fred. T. Ley & Co. in the Boston area. In 1921 he moved to Springfield and lived in that city and in Longmeadow for the rest of his life. His main career was in real estate management; he was president and treasurer of Security Realty Co. Fay was a Mason and, as a leader in civic affairs, was an officer of a hospital, a girls club, a savings bank, a cemetery and a Rotary club. He leaves a son, Fay W. Williams, Jr., of Windsor, Conn.; a daughter, Mary Ann Foster, of Moultonboro, N.H.; a brother, Howard Williams, of Los Angeles; and six grandchildren.

Harold Mayer left Milwaukee last May and moved back to the Northwest. He now lives at the San Juan Hotel, Bellingham, Wash. 98225. — **Charles H. Chatfield**, Secretary, 177 Steele Rd., West Hartford, Conn. 06119

15

Phil Alger was invited to present a paper at the Nikola Tesla Symposium held in Zagreb, Yugoslavia from July 7 to 10. Phil invited his grandson, Montgomery M. Alger, M.I.T. '78, to accompany him on the trip. They spent three days before the Symposium in Zurich, where they took a boat trip around the lake, visited the University, and enjoyed the view from the top of Mount Rigi.

The Symposium departed from the format Phil was accustomed to. "There was only one session," wrote Phil, "so the 100 papers were summarized by only a few speakers — a contrast to the U.S. custom of having parallel sessions. . . . I took 14 minutes to deliver my paper." In a long letter about the trip Phil gives an account of his paper, "The Induction Motor in the U.S. from Tesla to the Present Day" which traced Tesla's remarkable life beginning with his journey to the U.S. to work with Thomas Edison in search of a developer for his invention. (Those interested in Phil's entire letter may write to the *Review* office for a copy.)

On July 9 the Symposium members traveled to Gospic, some 120 miles south of Zagreb. That evening at dinner Phil "was seated at the head table, and introduced as *Mr. Induction Motor*, with a round of applause."

The final day of the Symposium was at "Smiljane, Tesla's birthplace, where there are the ruins of an old church in which Tesla's father preached." At ten o'clock an elaborate outdoor commemoration ceremony began in celebration of Tesla's 100th birthday. "The orchestra . . . and the chorus put on an excellent performance, after which representatives of the U.S.A., England, and others made complimentary speeches. Finally Tito spoke at some length. . . . There were hundreds of country people surrounding the activities, to whom Tito's message was carried by loudspeakers."

The next morning, July 11, Phil and his grandson flew to London where they toured Westminster Abbey and St. Paul's Cathedral, and visited a few old friends who shared with Phil their recent experiments with gyros and motors. Monty and Phil left for home on July 16.

Jim Tobey wrote of his visit to a seminar at Dartmouth: "I enjoyed the 11 days at the Dartmouth Alumni College, and took part in the seminars, not hesitating to correct faculty members at times." Sounds like Jim doesn't it? And I can see him now as a drill officer over in the old Irvington St. Armory.

Frank Boynton wrote from the nursing home in Los Angeles, "I recently talked with **John Gallagher** who seems to be in good health. I recently had a letter from **Nelson Stone** on Cape Cod. He said he had received a letter from **Art Bond** asking for John Gallagher. I have cause to remember how grateful I was and am to Nelson Stone because he took me to his home on Cape Cod for Christmas, 1913 when I was all alone and not well acquainted with the other Tech men. Needless to say it was a very kind and thoughtful thing to do and it was such a pleasure to meet his parents and have a visit there. Personally, I am doing quite well at this Episcopal Home. As a substitute for a *real home*, however, it is quite a poor second."

Orton P. Camp died in Waterbury, Conn., on August 12. He was a regular and generous supporter of all Class and Alumni activities. After receiving degrees from both Yale and M.I.T., Orton joined Platt Brothers in 1919, founded by his great-grandfather. He retired as president of the factory in 1968.

The Waterbury papers had glowing editorials about him, his interests and activities: "When it came to high regard for his native city, few could equal that of Orton P. Camp for Waterbury. . . . Camp was a member of the Board of Finance for a short time under two mayors during the 1940s and was a member of the Planning Commission.

"Many remember him best as the spark-plug of the one-time Waterbury Taxpayers Association; others will recall his support of and hard work for the Y.M.C.A. or the forerunner of today's United Fund, the Community Chest; or, perhaps, how he joined forces with others to secure for his hometown a branch of the University of Connecticut. Then again, it might be in industrial or real estate circles where he was known and recognized for his innate honesty, his business acumen, his overall know-how."

The sympathy of our class goes to Orton's family. — **Azel Mack**, Secretary, Apt. 26A, 100 Memorial Dr., Cambridge, Mass. 02142

16

We are still hearing good reports about our 60th Reunion. From **Doug Robertson**: "Just a line to tell you what a good time Bettina and I had at the Reunion. We look forward to more of them." Also, at the time this is being written, Doug's nephew, Mike Robertson, is challenging Senator Ted Kennedy in the Massachusetts senatorial race. From **Henry Shepard**: "Many thanks for the class picture. Many of us look younger than we are. Here's hoping we will be able to have another get-together next year." From **Earle Pearson**: "It was a great success and I enjoyed it tremendously." From **Hank Smith**: "The picture of the 'Red Coats' and others arrived safely. . . . It was a grand reunion and much appreciated by me." We've had several notes from **Harold Dodge** and are pleased to report that he and Grace are well. Recently, I spoke with **Vert Young**; he and Sylvia are well and looking forward to being with us next June for our 61st Reunion. From Hildegarde and **Jap Carr**: "Enjoyed being with you for the 60th — good old M.I.T. We are getting used to the 'North' and find it very pleasant."

From **John Fairfield**: "**Cy Guething** and I were reminiscing about the New England farm breakfasts of oatmeal and cream in the days B.C. (before cholesterol). Cy's cream was so thick and fresh from the separator that he often needed a knife to get it out." . . . From Cy: "We were sorry that we were unable to attend the reunion, particularly since that might be the last one for such a large group. Am I an optimist?" . . . In a letter of June 2, **Maury Holland** wrote that he wasn't able to attend the 60th, but "my heart and spirit was with my M.I.T. buddies at Chatham."

Charlie Lawrance wrote: "At my last birthday I discovered that I was 2 years old plus 80. Lois and I have retired to enjoy five children and 15 grandchildren and two probable great-grandchildren. Health still good, courage hopeful. Still proud of M.I.T. and 1916." . . . Joe Littlefield, '17, wrote in June: "Just out of hospital, but feel fine now." . . . From **Walter Metz**: "I wish everyone could enjoy the desert, the mountains, the climate and the golf courses here in Palm Springs, Calif." . . . **George Crowell** recently sent us a newsletter from the Kiwanis Club of Brockton which noted that "the only charter member of our club alive is George Crowell." George wrote: "The club was chartered in 1922. I have no reason to be particularly proud of this accomplishment. All I did was 'keep on breathing.' "

Early in the fall, we had visits with **Barney Gordon** and **Francis Stern**. Both are well and continue to be very active. In May, Francis had an operation for a cataract condition and later came up with a serious infection which returned him to the hospital. Now, he has progressed to the point where he could make the Hartford-Boston round-trip bus ride alone.

We regret to report the passing away of our classmate, **Herb Gilkey**. He had been a professor at Iowa State University. One of his associates there notified us of his death this past summer.

Many thanks for all your letters. Keep writing. — **Ralph A. Fletcher**, Acting Secretary, West Chelmsford, Mass. 01863

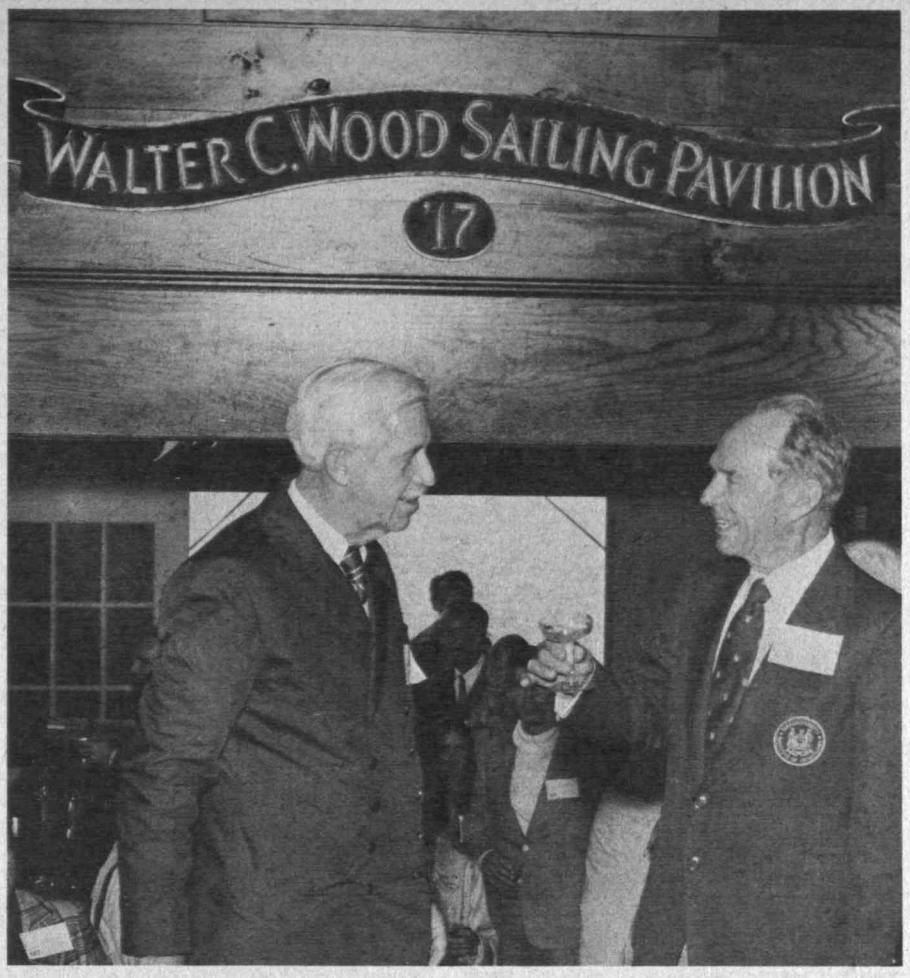
17

The contributions of **Jack Wood** to M.I.T. sailing were recognized at the dedication of the expanded Walter C. Wood Sailing Pavilion (*see page A6*). **Al Lunn**, **Ray Stevens** and **Stan Dunning**, and of course Jack's wife Helen, attended. The part that 1917 played in the pavilion program was also recognized and Jack is most appreciative of the support from our class.

Our 59th Reunion at Northfield with an attendance of 41 was, again, a very pleasant one. The weather was good and the foliage magnificent. The Connecticut River boat trip was again enjoyed and was not so silly this year. Helen and **Frank Butterworth** enlivened our social hours with a duet at the piano, prompting some dancing. With the cooperation of Warren Seamans of the Historical Collections a new film of M.I.T. was shown. It is a composite from the earlier days of movie making, one section having been obtained from the Library of Congress (*see page A14*).

Our funds appear to be adequate to support our 60th Reunion. Treasurer **Stan Lane** could not be present at our business meeting; he was recovering from an appendectomy. We missed him and Helen, his report and his pictures. President Lunn announced that our 60th Reunion would be held Thursday and Friday, June 9 and 10, in Cambridge with Friday night, Saturday, and Sunday on Cape Cod. More details will be forthcoming.

Phil Cristal made a motion that in consideration of his activities in the interests of the Class, our secretary be made a vice president. This motion was carried. A letter from the Student Financial Aid Office informed us that the Aldrin Scholarship student would again be Paul Lagace, '78, and that aid was also being given to the other three students assisted last year. We were happy to have our honorary members Jay and Kay Stratton and Don and Phyl Severance, '38, with us. Beautiful slides of a 1965 sailing-oriented trip to England with an M.I.T. sailing movie along with



The dedication of the newly renovated Walter C. Wood Sailing Pavilion on a raw and rainy day in early October was warmed by a celebratory toast between "Jack" Wood, '17 (right) M.I.T.'s first Sailing Master, and George Warren Smith, '26, Chairman of the Sponsoring Committee.

Jack Wood's running commentary gave us a very interesting and pleasant evening. Afterwards, most of our group watched the October 6 debate on T.V. with varying degrees of satisfaction.

Those attending were the **Beadles**, **Butterworths** and guest, **Cristals**, **Dunhams**, **Dunnings**, **Holtons**, **Hunters**, **Loengards**, **Walt Lyons**, **Neubergs**, **Paynes**, Severances, Strattons, **Wilsons**, **Wood**, and individuals **Penn Brooks**, **Henderson**, **Lunn**, **Peacock**, **Rogers**, **Seely**, **Ray Stevens** and **Wenzell**. Ladies, the question has been whether to include your names too. It is so good to have you with us, but the *Review* desires brevity, hence the omission.

The recent post card response of 77 from an enrollment of 146 was most gratifying and is indicative of the 1917 spirit. Notes to come will mention more names and comments from these cards.

Ray Brooks writes, "with diminishing energy I make no commitments and go places only at the last moment providing all indications say 'go,' but I intend to be at the 60th." . . . **Walt Beadle** wrote, "We regretfully sold our 35-foot yawl in August, but we have happy memories of the coastwise cruising just the two of us, from Elizabeth City, N.C., to Grand Lake, New Brunswick, Canada." . . . The **Bob Erbs** had to cancel out. . . . The **Ed Paynes** are now living in Boston.

The Class of 1918 again invited some classes to join them for a meeting and dinner at Endicott House on September 12. It was a pleasant affair with **Brick** and Edna **Dunham**, **Ray Stevens**, Al Lunn, **Jim Flaherty**, **Jess Rogers** and Stan Dunning attending.

Dick Loengard with **Will Neuberg** and **Clarence Seely** were the '17 contingent for the '16-'17 luncheon on September 14 in New York City. Excellent food was served in a special Chemists Club room where the meetings are held every second Tuesday. All classmates are invited, but advanced notice to Dick is desirable.

A note from Bill **Dennen Jr.** tells of the death of his mother, **Ruth**, on July 27. . . . **Charles A. Abels** died at Nashua, N.H., on August 4. . . . **Theodore W. Burkhart** died at Portland, Ore. on April 16, 1975.

Frequently questions arise regarding our class enrollment. Here are some of the answers. In 1913 we entered 415 strong. During the four years our number increased by 244 transfers from other colleges so our total enrollment came to 659. We graduated 366. Our present roll is 146.

It has been said that the one thing a man will not stand for is a lady in the subway. Your secretary got a message recently when a young lady offered him her subway seat. (And he accepted it.) — **Stanley C. Dunning**, Secretary, 6 Jason St., Arlington, Mass. 02174; **Richard O. Loengard**, Assistant Secretary, 21 East 87th St., New York, N.Y. 10028

18

It is Sunday, October 17 as I start these notes. Earlier today I drove by M.I.T. The river was bursting with activity — sailboats and a regatta. I could not help thinking how our Tech has grown with buildings from Cottage Farm bridge to West Boston bridge — and wishing that many of you far from Cambridge could come here and share in feeling the majesty of our Alma Mater as it looks across the river to Boston. It would mean much more to those of us who spent two years in the Copley Square buildings.

The most exciting event of the past few months was the 1976 mini-reunion which took place at Endicott House on September 12. We were especially happy to see our out-of-state classmates. They included: Frances and **Pete Harrall** and **Jim Bugbee** from Baltimore; Jean and **Mal Baber** from Philadelphia; Winifred and **Summer Wiley** from South Harpswell, Maine; Elinor and **John Kilduff** from New Hampshire; and **Sidney Blaisdell** from Great Barrington, R.I. The Massachusetts group included: Elizabeth and **Julie Howe**, Mildred and **Charlie Watt**, Marion and **Herb McNary**, **Pete Strang**, **Julie Avery**, Dolly and **Eli Berman**, Gladys and **Len Levine**, Marie and **George Sackett**, and Selma and **Max Seltzer**. In addition, we had guests from the classes of 1917, 1919, and 1920. We were privileged to listen to Dean William Pounds of the Sloan School of M.I.T. He spoke in a most interesting fasion of his school, and about the economic problems facing us all. We also had the pleasure of seeing the preview of the movie "Take Me Back To Tech", prepared by the Historical Collections Department of M.I.T. (*See page A 14*). The greatest dividend of the day was renewing old friendships, making us all more closely knit members of the M.I.T. family.

A week later several of us — Elizabeth and **John Kilduff**, Gladys and **Len Levine**, **Dorothy Rossman** and Selma and **Max Seltzer**, on August the 1976 Alumni Officers Conference. I was particularly impressed with the talk by Professor Ann Friedlander of M.I.T. on the economic climate of the Commonwealth of Massachusetts.

News from **John Abrams**, Bishop, Calif., is always stimulating. John just returned from his "annual trek to find surcease from mundane cares in the endangered wilderness." John reports that he is beginning to see some positive results from his work over the decade in protecting the environment.

I record with sadness the death of one of our most loyal classmates, **Sax Fletcher**, on August 13, 1976 in Greenfield, N.H. Sax was the former vice chairman of the board of directors of Midlands-Ross Corp., White Plains, N.Y. It was my privilege to have been close to him these past few years; he had a tremendous reservoir of human kindness. I shall miss him, as will all of you who knew him.

Through the courtesy of Julie Howe we learned that **Craig Hazelet** is now in a nursing home in Louisville, Ky., after several serious operations.

The Class of '18 gathered at Endicott House in September for a mini-reunion.

Mail can be addressed to him in care of his daughter: Mrs. John Clark III, 520 old Stone Ln., Louisville, Ky. 40207

News from Elizabeth Quinn recorded the death of her father, **Jim Irwin** on July 29, 1976. "Before retiring in 1960, he was vice president of the United States Cold Storage Corp., and was considered internationally as an authority and top consultant in his field." — **Max Seltzer**, Secretary, 60 Longwood Ave., Brookline, Mass. 02146; **Leonard Levine**, Assistant Secretary, 539 Washington St., Brookline, Mass. 02146

19

Harry Cikins, 79, of Brighton, Mass., died in July, 1976. He was born in Russia, came to America at an early age, graduated from Boston English High School and Northeastern University. Following graduate work at M.I.T., he worked as a civil engineer. Later he became a consultant for the Metropolitan Life Insurance Co., where he was employed for 30 years. He leaves his wife and three sons.

Word was received of the death of **Edward F. Deacon** at Hilton Head Hospital, S.C., on June 18, 1976. He was 84 years old. Charles I. Lawson, '20, a close friend of Ed's at the Delta Upsilon house and in the 301st Engineers at Camp Devons, France and Germany, furnished the following information: "Ed had a varied and distinguished career with presidencies of Brecht Co. (St. Louis), Climax Engineering Co. (Clinton, Iowa), and the Internal Combustion Engine Institute (Chicago)."

I was only recently informed that **Russell Hamilton** died on July 1, 1975. My records (our "25 years after") show he was a chemist for Tremont Nail Co. in West Wareham, Mass., and later in Bloomfield, N.J. According to the 1975 Alumni Register, Russell had retired and was living in Phoenix, Ariz.

Fred Hewes writes from 1195 Thurston Ave., Los Altos, Calif.: "My wife Claire and I have lived here in retirement, close to the Naval Air Station, Moffett Field, where I was on duty from 1932 to 1935 during its construction. It is now the hub of anti-submarine warfare patrol operations in the Pacific. We continue to enjoy May and October visits to my wife's original home in western Nevada." For those who do not remember, Fred is a retired Captain of the U.S. Navy who served with naval aviation shore facilities in U.S., Hawaiian Islands, Panama Canal Zone, and Alaska. He became Assistant Director, Atlantic Division, of the Bureau of Yards and Docks, and later, Public Works Officer of the naval Operating Base, Fifth Naval District, Norfolk, Va.

Dick Holmgren writes, "I am retired but active in trailering and traveling. We took a tour of Indonesia and Thailand in the spring, and spent the months of August and September traveling in our airstream trailer through the Northwest and Vancouver Island in Canada. I included some salmon fishing at Westport, Wash. Am now looking forward to a tour of New Zealand, Australia, Tasmania, and some of the south Pacific Islands in November and December. Feeling fine and looking forward to our 60th Reunion." Dick has had a very active career in civil engineering, he was chief engineer of the New Hampshire Water Resources Board in Concord, where he constructed several dams for water supply storage and flood control. He also was project engineer on construction of floating drydocks for the Navy at Alameda, Calif., and later consulting engineer for James M. Montgomery on the West Coast.

A note from **George B. Hirsch** of Cedar Grove, N.J.: "I am still a bachelor. My last job was 26 years with Brown and Sharpe in charge of machine design. I retired in 1961 and took an 18,000-mile, 15-month auto trip visiting every country in Europe. In 1965, I took a 42,500-mile air trip around the world to 22 countries. In 1969 I took a 6,000-mile auto trip through the South. This was cut short by a heart attack in Amarillo, Tex. Feeling tolerably well now but no more traveling."

From Bradenton, Fla., **Erwin M. Kenison** writes, "I shuffle most every day, and play bridge and rummy. I feel pretty good. Drive around town and take a lady friend out to dinner." . . . **Howard H. McClintic, Jr.,** sends his best, and also writes that he is still happy to have graduated from M.I.T.

Evelyn Kitchin writes from Brunswick, Maine,

about her husband **Donald W. Kitchin:** "Sorry to have to report that Don has been in and out of the hospital since March. He has had several heart attacks. We are now waiting to get him into a fine nursing home here in Brunswick, a short drive from home. It's sad to see Don so frail. Our best to all."

Our reunion chairman, **Will Langille,** writes from Gladstone, N.J., "A few hasty notes concerning myself: I passed the 81st year and am closing in on the 82nd; active every banking day as Chairman of the Board (State Bank of Raritan Valley, Raritan, N.J.), not all in chair, however; still active at our farm home planning farming on some 25 acres; our next reunion is coming into view (only two-and-a-half years away to our 60th), so I will be setting up some preliminary meetings in Boston and New York in the very near future. If you will be in the area any time soon, please let me know."

Gladys Wiswall of Woodstock, Vt., informed us of the death of her husband **George Wiswall** in February, 1975. She wrote that George "always enjoyed receiving *Technology Review* and learning about old friends and classmates."

Your secretary had a wonderful trip in May. I spent six days in London and took a Swan Tour of the Greek islands for two weeks. The summer saw us in Chautauqua for two months, then Maine, New York, Washington, and finally back to Florida by October. I talked to **Royden Burbank**, **Paul Sheeline**, and **George Michelson** while passing through Boston and found them all well and happy. I saw **Nelson Bond** in Schenectady, N. Y., and talked to **Edgar Reynolds Smith**'s widow Grace in Lottsburg, Va. Best wishes for a good winter. — **Eugene R. Smoley**, Secretary, 50 East Rd., Apt. 11E, Delray Beach, Fla. 33444

20

One of the very best reasons for living in New England is proximity to the Institute; as proof, the several recent occasions for happy meetings with members of our class. One was a delightful mini-reunion at Endicott House in Dedham. This annual affair, composed of the classes of '17, '18, '19 and '20, was well attended by both husbands and wives. Our class was duly represented by Prexy **Norrie Abbott** and Betty, Mina and **Perk Bugbee**, **George Wilson**, and of course, your secretary and his Amy. I wrote to a number of nearby classmates about this pleasant gathering; but if you did not hear from me and would have liked to come, be sure to let me know so I can advise you of the next meeting.

Ed Ryer said that he and Beth would have liked to come but were in Maine at the time. **Frank Maconi** couldn't make it because of conflicting engagements. Frank writes that since full retirement, the flower and vegetable gardens keep him very busy. At the time of his retirement he was made an honorary member of Rotary for his successful efforts in starting Rotary night at the Pops, and then running it for seven years. He and Kay attended the Rotary International convention in New Orleans last June. Frank, who had organized the Antiques Fellowship for Rotary, managed its booth at the convention. Frank's home is at 33 Bonnydale Rd., Leominster, Mass.

Barbara and **Bill Dewey** couldn't come to the mini-reunion because they were moving from their summer place in Ashfield, Mass., to their home in Springfield. Bill and Barbara should now be at Treasure Island in florida. Bill says they have four grandchildren in college. . . . Pat and **Buzz Burroughs** missed the reunion because they were involved in a golf tournament.

A second occasion for meeting was the Alumni Officers Conference, where I had the pleasure of a visit with **George Morgan**, who came all the way up from Beaumont, Tex. George has been a loyal and valuable alumnus in that area. I am glad to say that he appeared to be in good shape. Also present at the A.O.C. was one of our redoubtable Class Agents, **Al Burke**, whom I had previously seen on TV officiating at the Longwood tennis matches. Al still plays a lively game of tennis almost every day. More power to him!

Finally, an extra special party at the fall meeting of the M.I.T. Corporation marked the unveiling of a bronze plaque, adjacent to Room 10-250, listing all former Alumni Association presidents. It was a pleasure to see **Ed Ryer** and the late **Al Glassett** listed and especially to greet Ed and Beth in person; both are looking very fit.

A welcome letter from **George Des Marais** tells of his moving to 295-N Sharon Way, Jamesburg, N. J. George had lived in East Orange for nearly 50 years. He says he felt a pang relinquishing his huge accumulation *Technology Reviews* and 25-year collection of Educational Council material. George and Lois are happy with the change to this leisure community, Rossmoor, where they are finding a number of M.I.T. men and their wives.

Another bit of good news is about our distinguished classmate **Herb Fales.** Herb celebrated his 80th birthday last July. He received hundreds of messages of good will from all over the world, including one from President Ford whose birthday came on the same date. Herb was recently awarded a Doctor of Science degree from Arizona State College, where he has been active on the meteorology staff. Before retirement, he has had a long and illustrious career in metallurgy and was vice president of International Nickel Co. He still enjoys flying his own private plane.

I have just learned of the death of **Isaac B. Simon** of 6101 16th St. N.W., Washington, D.C. He leaves his wife, Marjorie.

And now, congratulations are due to remaining classmates. You have survived 14 elections, four wars, Prohibition, the deep Depression, the nuclear age and taxation. An interesting and eventful 1977 to you all. — **Harold Bugbee**, Secretary, 21 Everell Rd., Winchester, Mass. 01890

21

The news of **George Chutter**'s death came to your secretary while he was vacationing in New Hampshire and after class notes had been sent in for the October/November *Review*. Consequently, the news item was brief. Letters regarding his death subsequently came in from about ten classmates, to whom I express thanks for keeping me informed. The class was represented at the memorial service by **Ed Dube**, **Don McGuire**, Hazel and **Whitney Wetherell**, **Don Morse**, Anne and **Mel Jenney**, **John Mattson**, and Gladys and **Paul Rutherford** — all sitting in a group, with the men wearing their red M.I.T. jackets. Many moving tributes were paid to George for his dedicated work on the Cape Cod Council of Churches, the Dennis Union Church and the Gideons International. George attended all of our reunions as far back as I can remember, and was a warm friend devoted to M.I.T. We shall miss him.

A clipping from the financial page of the *Tulsa Tribune* is headed, "You're a 'grand' guy yourself, **Bill Sherry**." Quoting from the article, "William J. Sherry, veteran oil operator and broker of Tulsa who has been active in selection of the 'Grand Old Men' special awards by the International Petroleum Exposition for over 20 years, today received a special award of his own from the I.P.E. — the first ever 'Distinguished Service to Oil Industry Pioneers' award." In past years Bill has received the M.I.T. Beaver Award and the Distinguished Science Medal from the University of Notre Dame. Congratulations Bill!

A letter from **Dick Morris** of Santa Monica, Calif., to Assistant Secretary **Sam Lunden** tells of an extensive trip he and his daughter took, touring South America and Africa. Dick lost his wife Marion in the fall of 1974 following a stroke in the spring. **Sam Lunden** spent this past summer at their cottage on Cape Cod. He and **Bob Miller** arranged an M.I.T. luncheon in September at the Cove Motel in Orleans, which brought out two other '21ers, **Whitney Wetherell** and **Don McGuire.**

Elizabeth and **John Barriger** had plans for a big celebration of their Golden Wedding Anniversary on September 25 in St. Louis. But John required major surgery late in August, postponing the celebration until December 4. His daughter wrote that he is making a good recovery and hoped to soon be back in harness with the Rock Island Lines. Incidentally, John is having his M.I.T. '21 jacket repaired by Croston of Boston after getting an irremovable ink spot on it from his ballpoint pen.

Irving Jakobson took his annual summer cruise up New England way on his sailboat *Dowsabel* in July. Jake attended the Alumni Officers Conference at M.I.T. in September and reports that Emma and **Al Lloyd** and Ed Dube were there also. Jake said that the activities of the Institute are exceedingly impressive these days, which makes him feel constructive forces are at work in Cambridge. Jake was at M.I.T. again in early October for the dedication of the new sailing pavilion and new dinghy fleet. Jake donated one of the new dinghies, as did Peter Felsenthal, '54, in memory of his father **Robert Felsenthal**. Jake's last bit of news was about a recent postcard he received from Tarpon Springs, Fla., signed by Becky and **Elmer Campbell**, Billie and **Tom Bartram**, and Graciela and **Heller Rodriguez**. The occasion was a convivial luncheon date.

A good note from **Cac Clarke** says, "We're well, happy and continually busy. Maxine has two art shows in the offing. I'm involved in the combined Bicentennial Brielle Day and Crafts Festival on September 11 — our last big Bicentennial bash for this year. I've had a couple of fleeting phone calls with **Munnie Hawes**, when he wasn't off golfing or duck shooting. All is well with him and Alex."

A postcard from Zurich from Helga and **Jim Parsons** told of a six-week cruise and tour in Europe this past summer. Wrote Jim, "It's getting a bit arduous and we're looking forward to getting home."

An Alumni Fund envelope brought in a morsel from **Horace B. Tuttle**: "Five great-grandchildren now. I'm working in the town of Bloomfield, Conn., for larger Senior Citizen meeting quarters — 175 to 250 of us meet every Tuesday."

We sadly report four more deaths: **Charles E. Mendinhall**, Wilmington, Del., July 6, 1976; **Charles A. Morss**, West Hartford, Conn., September 10, 1976; **John R. Gallimore**, Cleveland, Ohio, September 17, 1976; and **Albert J. Hanley**, Harrisville, R.I., September 19, 1976. Mendinhall was with our class only during freshman and sophomore years. He worked for both DuPont Co. and Delaware Power and Light Co. before entering the real estate business in 1929. He achieved national recognition among real estate men when he set up courses in real estate education at Goldey Beacon College in Wilmington. Morss graduated from Harvard in 1919 and from M.I.T. in 1921. He worked for Curtiss Wright on jet engine development in the 1930s and then spent the rest of his business career for Pratt and Whitney Aircraft on engine design. Hanley spent most of his business career with Respro, Inc. as Technical Director, and with General Tire and Rubber Co. The sympathy of the class is extended to their families.

In last month's class notes, it was recorded that **Robert Miller**, our class photo-historian, left our class album with the M.I.T. Historical Collections, and would be available to our class at any time upon request. Bob is inviting any classmate with good pictures of our 55th Reunion to lend or send him copies for possible inclusion in the album. — **Sumner Hayward**, Secretary, 224 Richards Rd., Ridgewood, N.J. 07450; **Josiah D. Crosby**, Assistant Secretary for Florida, 3310 Sheffield Cir., Sarasota, Fla. 33580; **Samuel E. Lunden**, Assistant Secretary for Calif., Lunden and Johnson, 453 South Spring St., Los Angeles, Calif. 90013

22

Our mail has been interesting because of various ideas for the 55th Reunion in June, 1977. Our President, **Parke Appel**, has written considering the Colonial Hilton Inn at Wakefield, the Hotel Wentworth on the New Hampshire coast and the Spalding Inn in Whitefield with "Bunt" Spalding. Many have written to Parke about holding the Reunion on the Campus as we did for the 50th with cocktail parties and social events in the dorms as well as the June 9 Pops at Symphony Hall and June 10 Alumni Day. If our Reunion is held in Cambridge, the planning would be greatly assis-

ted by the Alumni Office staff. It is also felt that the Reunion on Campus will attract the largest number. Parke is getting votes from **Don Carpenter, Earl Eacker, Chuck Brokaw, Yard Chittick, Oscar Horovitz, Ab Johnson, Mac McCurdy, Bill Mueser,** and **Fearing Pratt**. We have also written to **Frank Kurtz** in Delray Beach and others (by the way Frank spent some time in the north this August visiting sons and family). Your opinions and desires should be sent to Parke D. Appel, 1000 Tarpon Center Dr., Venice, Fla. 33595.

We enjoyed receiving the August issue of *Northwest Sea*, a western boating magazine, which included a four-page write up with pictures entitled "Horace McCurdy and *Blue Peter*: Friends For Life." Since your Secretary had the privilege of an afternoon on the *Blue Peter* with Catharine and Mac, we found this especially enjoyable reading. *Blue Peter* is a 96-foot classic power yacht which he rescued from army surplus in 1948. After five years of restoration and added equipment, *Blue Peter* now is one of the most functionally-equipped and best-known yachts in northwest waters — and so is Mac. He is now updating his book, *The H. W. McCurdy Marine History Of The Pacific Northwest*. This covers the years 1895 through 1965. His new volume will cover the ten years through 1975, a period of dramatic change along the waterfront. Mac considers the growing popularity of diesel engines and changes in hull design from displacement to planing hulls as the most significant innovations he has witnessed in boating.

We have been receiving literature about the new M.I.T. Fund Campaign and regret the absence of many classmates in leadership positions. This is quite a change from our historic stance of always being up in front in all phases of campaigns. . . . Yardly Chittick has written from Ossipee, N.H., of a news item telling of the death of **F.W.** (Luke) **Walton**, North Edgecomb, Maine on September 20 at Waldoboro Nursing Home. He was a former executive with Young & Rubican, but moved to Maine upon retirement to operate a nursery and landscaping business for a number of years.

Ruth and **Yardly Chittick** visited **Ab Johnson** at Crystal Lake, Mich., "for a great week of golf." They have enjoyed their New Hampshire home. . . . **Raymond E. Miskelly** of Yarmouth Port, Mass., has written of services held in September for **Herbert C. Ham**, former purchasing agent for Eaton Paper Corp. in Pittsfield. Ray also reported a visit to the Spalding Inn Club in September of 1975 for a week as part of a fall foliage trip in Vermont and New Hampshire. **Larry Davis** was there and at the same time they had a "Mini-Mini" Reunion with Randy and his wife including Red Coats. . . . We also had heard from Alberta Bard who attended our 45th and 50th Reunions. She asks for a picture of Herb at the 45th seated at a low round table with a group which one of us must have in our files. If you would send it to Buffalo, it will be properly forwarded.

Our sympathy has been sent to Helen G. Welling for the loss of our Classmate, **Charles McKay Welling**, a native and resident of North Bennington. Charles was retired Secretary-Treasurer for the Decorated Metal Manufacturing Co. of Milltown, N.J., and had retired in 1966. His hobbies included model railroads and photography as well as taking railroad trips across Canada, England, Wales, Switzerland, and the Orient. He had enjoyed winters in Largo, Fla., for some years. He is also survived by a daughter, two grandsons and two brothers.

The sympathy of our Class also goes to the families of **Percival C. Keith, Jr.**, Peepack, N.J.; **Boyd M. Begg**, Walnut Creek, Calif.; **Osborne A. Browne**, Colrain, Mass; **Wilhelm D. Styer**, Coronado, Calif.

On a happy note, Buffalo has had lots of rain all summer leaving us in October and November with perfectly beautiful scenery with greens, reds and brown coloring. Come up and see us some time. — **Whitworth Ferguson**, Secretary, 333 Ellicott St, Buffalo, N.Y. 14203; **Oscar Horovitz**, Assistant Secretary, 3001 South Course Dr., Pompano Beach, Fla. 33060

23

Herman Bruson, chemical consultant and inventor, was named 1977 winner of the American Chemical Society's $2,000 award for creative invention. The announcement was made at the Society's meeting last August in San Francisco. Herman holds more than 325 U.S. patents in the field of complex organic chemistry, and was associated with the Olin Mathieson Corp. of New Haven, Conn., from 1952 until his retirement in 1966.

A postcard from **Philip Coleman** reports interest in going back to the Chatham (Mass.) Bars Inn for our 55th reunion in 1978. Several of us have agreed with the proposal, but consensus is changing now in favor of Cambridge, where we won't be obliged to travel back to Boston for the Pops concert and other Alumni Day events. You will all hear more about this in due course.

Last July we had a three page letter from **Dale S. Davis** describing his nostalgic memories of life in Boston before and during his undergraduate days at the Institute. He made much of the SGWMTPG, which translated of course means the Society of Gentlemen who Married their Prom Girls. Unfortunately, it is much too long to abstract or summarize, given *Technology Review* policy. I am sure that many who were in the Department of Chemistry and Chemical Engineering would take pleasure in corresponding with him. His address is P.O. Box 6, Bailey Island, Me., 04003.

We have learned that **Chaplin Tyler** has collaborated in the publication of a book, *Managing Innovation* (John Wiley and Sons, 267 pages) with Edwin A. Gee, a vice president of E.I. duPont de Nemours. The authors analyze product development from Archimedes' "Eureka" to the consumer's purchase. Chaplin holds degrees from Northeastern University, Boston University, and M.I.T. He has served as a management consultant, specializing in financial analysis, venture investment, and corporate planning. In 1961 he was awarded an honorary degree of ScD. by Northeastern University.

Howard F. Russell continues to support the work of the Silver Wings of World War I, now functioning as adjutant for the second time around. He keeps in close touch with **Harold Gray**, who lives nearby in Sun City, Ariz.

Our notorious and unpredictable classmate, **Alan R. Allen** has come up with another surprise. After living for 35 years in the Shelton Towers across the street from the Waldorf-Astoria, he, with his elderly neighbors, was given a notice of eviction. "No dice," said Alan, who is chairman of the tenants committee. "This is our home. Here's where I keep my vegetable health foods, my vitamin pills and my Dead Sea bath salts. I promised our classmates that I would be back at our 75th reunion, and I'm going to make it." So Alan and the other seven tenants were granted extensions while the Shelton Towers is being converted into a Holiday Inn, after which they will all have rooms at the present low rates of $3 per day. As Alan saved their ship when it was foundering he has been granted a special lower rate for life (under the protection of the city's rent control laws). By this time, Alan has silver white hair shoulder length over each ear. While we might not recognize him, we all recognize his perennial ability to be central in solving unforeseen circumstances.

We are sorry to hear of the death of **Lawrence Jordan** of Branford, Conn., on August 5, 1976. He received his B.S. in Chemistry with our class in 1923. He served in the U.S. Army in World War I and was associated with the Olin Corp as a chemist. Before attending M.I.T. he graduated from Brown University.

Eugene V. Ward of Stanford, Calif., died on February 2, 1976. Born in 1882, he recieved a B.S. degree at Cooper Institute prior to attending M.I.T. and received his B.S. in Architecture with our class. He was lecturer in Architectural Engineering at Stanford University, becoming Emeritus in 1948.

John Harvey Westren of Toronto, Canada, passed away on February 1, 1976. He studied chemical engineering at the Institute after receiving B.A. and B.S. degrees from Toronto University. John was a manufacturing official with the Dunlop Tire and Rubber Goods Co. of Canada.

Elwood A. Windham of Clinton, Conn., died on April 24, 1976. He was a consulting engineer, receiving a B.S. degree from University of Michigan and M.S. from M.I.T. During the 1920s and 1930s he was associated with three firms in Detroit: Detroit Decorative Supply Co., Ltd, Union Central, Inc., and Bruce Palmer, Inc. Later he was associated with the Surface Combustion Corp., first in Toledo in charge of engineering, and later in New York as District Manager of the Air Conditioning Division of that company. — **Thomas E. Rounds**, Secretary-Treasurer, 990A Heritage Village, Southbury, Conn., 06488

24

As I plant myself before my electric word machine, I find that news has followed the stock market slump. A note on his alumni Fund envelope says **Al Roig** has "On June 25th, become a great-grandfather — baby boy born on June 25 to this oldest granddaughter." Must be the fertile atmosphere of Puerto Rico.

Dave Kanter, Great Neck, N. Y., writes his fervent hope that a favorite grandson will be admitted to the Institute after a November interview. Dave spent a year with us but had to leave due to family circumstances. Subsequently he engaged in engineering and manufacturing ventures, "conditioning" his grandson for matriculation.

Herb Stutman passed away after a long illness in Brookline, Mass., on October 8, 1976. He was Chairman of the Board of Stutman and Margolin, manufacturers of tailored dresses. He joined us from Tufts College and spent two years in Course XV. His son, Dr. Leonard J., M.I.T. '48, West Nyack, N.Y., became nationally prominent through a *Time* magazine article describing research on blood coagulation. Herb was active in several organizations, including the Stein club.

The Alumni Officers Conference on September 17 and 18, 1976 was attended by **Gordon Billard** and Velma, **Jack Cannon, Bill Orreale** and Betty, **Ed Moll** and Rene, **Frank Shaw** and Barbara, **Herb Stewart**, and **Russ Ambach**. It provided opportunities to see M.I.T. today, to renew acquaintances, and to share ideas with other alumni, faculty, and staff. A special event was the Saturday breakfast for Class Secretaries and assistants, hosted by the *Technology Review*, followed by a most fascinating demonstration of *The Tech*'s phototypesetting equipment by Mark Munkacsy, '78, where the type for this column, as well as *The Tech* and other publications, is set. Our one suggestion is that larger type is preferable for the older alumni.

A last-minute message from **Paul Cardinal** is a copy of his letter of October 7 to **Pret Littlefield** in Connecticut. It chiefly concerns the Fifth Florida Festival at Fort Lauderdale on December 8 and 9, being staged by the **Gordon Harveys** and **Paul Millers**. Eight reservations are firm, but a dozen other Floridians are expected and possibly Al and Saro Roig. Paul has been traveling to New Jersey, San Francisco, Chicago, and way stations.

The fame of many of our classmates outlives them. A recent instance is that of **Edmond Bruce**, whose name appeared last July in the *New York Times* in an extended obituary of Dr. Harala T. Friis, who is credited as the father of radio astronomy. The obituary named our Edmond the major contributor to the achievements of Dr. Friis, prior to his death in November, 1973. Ed was a prominent member of the M.I.T. Radio Club and spent long hours operating its radio station. After graduating, he joined Bell Laboratories where he apparently spent his entire career.

A card from Mary Daily advises that Robert G. Daily has moved from Pennsylvania to Phoenix, Ari. She says that Doc has limited vision but swims every day, recently attended an M.I.T. dinner, and enjoys the *Review*.

From August 26 to September 1, **Herb Stewart** was in Paris as an officer and American Delegate to the biennial International Congress of Large High-Voltage Systems in the UNESCO building. There were 2,300 delegates and many wives from all parts of the world. Herb and Winnie toured

England the following two weeks, rewarding Avis by running up 1,100 miles visiting friends and relatives.

Frank Shaw, our Class President, has slowed to second gear for a few months while recuperating from a cataract removal but continues to promote his fireplace "Logger" business. — **Russell W. Ambach**,Secretary, 216 St. Paul St., Brookline, Mass., 02146;**Herbert R. Stewart**,Co-Secretary, 8 Pilgrim Rd., Waban, Mass., 02168

25

President **Chink Drew**, Class Agent **Jim Howard**, **Courtney Worthington**, and I attended the Alumni Officers Conference on September 17 and 18. Chink left a few days later for California where he spends the winter. He summered at his home in New Castle, N.H. On September 21 the first alumni gathering on Cape Cod took place with 65 in attendance. Our class was represented by **Pete Goble**, **Will Mahoney**, and yours truly. **Ken Proctor** had planned to join us but found he had a conflicting engagement at the last moment.

Tom Killian writes that he is continuing teaching and research in power engineering at Portland State University in Oregon, where he is a Professor of Electrical Engineering. He retired as a Rear Admiral, U.S.N.R., in 1967. He serves as Chairman of the Education Committee of the I.E.S. . . . A note from **Kamy Kametani** explains that his trip to this country has been delayed and his golden wedding trip to Europe has been postponed until next spring.

The *Herald News*, Fall River, Mass., reported several months ago that the Rev. **Robert Stansfield**, a retired minister, had accepted a call from the Baptist Temple to serve as assistant to the pastor in a nursing home and visitation ministry. Following graduation, Bob joined the Army as a commissioned officer and upon discharge worked with several engineering firms in the Boston area. While a captain in the Army, he made his decision to enter the ministry and studied at Gordon Divinity School, Syracuse University, and Miller Institute. He had pastorates in North Reading and Dorchester, Mass.; Auburn, N.Y.; Jackson, Mich.; and Baltimore. He was a former staff evangelist for New England Fellowship and president of the South Shore Biblical Institute. He reentered the Army during World War II and served as a chaplain with the combat infantry troops in Europe. He is a holder of a bronze star medal for valor in the Battle of the Rhine. He is currently Vice President of the Christian School of Greater Fall River and is conducting bible studies and chapel services in six area nursing homes as well as holding classes in Swansea and Highland Heights. Bob is a busy man in his retirement.

The *Republican*, Springfield, Mass., published a column a few months ago about **John Magee**, president of John Magee, Inc., an investment counseling firm in Springfield. John is an author and publisher and has clients from many parts of the world. He describes wise investment policy as follows: "One doesn't necessarily shoot for the biggest pay-off, the largest winnings — one looks for the strategy that will offer the risk of small and limited losses on the one hand, plus the opportunity for hoped-for profits."

My attention has been called to an article which appeared in the Boston Sunday *Globe* on July 11. It was written by **Willard Allphin** and gives a most interesting and instructive story of "Life on a Freighter." Willard is listed as a freelance writer residing in Danvers, Mass.

It is my sad duty to note the deaths of five classmates. **Ralph Ilsley** passed away on June 8, 1976, having suffered a stroke several weeks earlier. Ralph was one of the few geologists in our class. He returned to M.I.T. during the 1930s to obtain his doctorate. Prior to his retirement he was for many years employed as a consultant to the U.S. Armed Services Explosives Safety Board in Washington, D.C.

Francis M. Corliss died on August 22, 1976, in Palo Alto, Calif., where he had lived since retiring from the General Electric Co. in 1962. Frank had been with International General Electric during most of his working years. While in the Philippines, he and his late wife and their baby daughter were taken prisoners during World War II. After being liberated in February, 1945, he and his family returned to Boston, then I.G.E. sent him on to Mexico and Spain.

Stephen V. Gilligan, whose home was in Santa Barbara, Calif., died of a sudden heart attack in Scituate, Mass., on September 16, 1976. Steve had come East to attend the funeral of his son Stephen, Jr., 41, who had suffered a heart attack while playing tennis. Steve was Personnel Manager of the Regional Boston Post Office for 15 years before his retirement in 1970.

Horace E. Weihmiller passed away on July 10, 1976, at a nursing home in Rockville, Md., where he had been recuperating for a month following hospitalization. Weih had a most active and interesting life working in the field of aeronautics. I believe many of you may want to know more about Weih, and I will report further in the next issue.

Belatedly, news of the death of **Harold D. Werner** has reached the Alumni Office. Harold passed away on October 10, 1975, in Erie, Penn.

Let me close on a more pleasant note: to all of you a Merry Christmas and best wishes for 1977. — **F. Leroy (Doc) Foster**, Secretary, 35 Woodland Way, P.O. Box 331, North Chatham, Mass. 02650

26

This is a month to report news from classmates about our 50th Reunion. Fortunately, many have written, which will save me valuable time. Ruth goes for her total hip replacement tomorrow (October 18), so it's a little hectic around this Pigeon Cove establishment.

Class President **Dave Shepard** wrote that he received a letter from **Ben Richardson** just after he returned home from a vacation in Colorado. Ben explained why he could not come to the reunion: "In early June I found that I had lost control of my limbs, so I turned myself over to the doc to find out why, and what to do about it. The 'why' is a tumor on the brain. The 'what to do' has been cobalt rays to shrink the tumor, which seems to be doing that. It was a great disappointment to me to have missed the reunion." Dave replied to Ben by phone and by letter, extending the best wishes of the class for his speedy recovery.

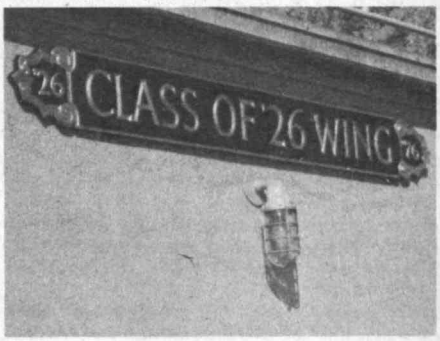
Jud Biehle has written from Hawthorne, N.Y.: "Carolyn and I thoroughly enjoyed the reunion. Just wish that we could have heard a '76 revival of the famous **Shepard-Mancha** banjo duet. We went on from Chatham to a family reunion in Georgia, a nephew's wedding in Chattanooga, and finally, to Houston for two weeks with our grandsons."

Jim Offutt has written from La Grange, Ill.: "The 1926 50th Reunion was a great experience and all who had anything to do with the arrangements are to be commended and thanked. . . . Do you suppose **Jim Killian** kept a record of his closing speech or was there some alert member of the Class that recorded the talks at the dinner Saturday? If so, I am sure many members of the Class would like to have a copy. At least put the poem of Housman or its name in the class notes. It was most effective and appropriate for this great occasion. Hope we can all make the 55th." Jim mentional that he was disappointed in the black and white Chatham Bars class picture. We have many color prints of individual classmates and groups that were taken at reunion and, of course, there is the Audio Visual record that we have not put together for editing; that is a priority item for the reunion committee.

And next a postcard from Israel! "Greetings from Ruth and **Louis Taylor**. Still talking about our wonderful 50th. On to the 55th!" Louis even suggested a reunion in Israel, but isn't Bermuda a great deal closer? . . . "**Pete**" **Ruggles** sends us the following note: "Cecil and I sure appreciated the effort and arrangements made for our 50th. Finally received the class photo — some fun using a glass (magnifying) and recognizing different ones of the gang."

The Alumni Officers Conference was held on

"A tall oak in a forest of loyal alumni, his lifetime of service to the Institute stands as an inspiration to all his fellow alumni." The 1976 Bronze Beaver Award is presented to David A. Shepard, '26 (right), by Edward O. Vetter, '42 President of the M.I.T. Alumni Association, at the Alumni Officers' Conference.



The above quarterboard with gold leafed letters now graces the east wing of the Sailing Pavilion. Funds for renovation of this wing were provided by the Class of '26 as part of their 50-year gift to M.I.T.

Homer A. Burnell, '28, receives his 1976 Bronze Beaver Award from Alumni Association President Edward O. Vetter, '42. The citation read: "His distinctive record of loyal and constructive support of M.I.T., especially his consistent support of major Chicago events and the Chicago Alumni Fund Council, goes far beyond the formal titles he has held."

September 17 and 18 (*see page A9 for a full report*). One occurence at the Conference should be of great concern and pride to our class: the 1976 Bronze Beaver was presented to **David A. Shepard**. Congratulations to our respected class president.

Again, you will read elsewhere in the *Review* (see page *A6*) about the dedication of the expanded Sailing Pavilion on October 2. Since the class has a vested interest, let me tell you that a tent was erected atop the Class of '26 wing for the dedication ceremony. But the tent would hold only 275, and 400 came. Loudspeakers and chairs were set up in the New Shore School below, which was given by our **Bob Dawes** and his wife Evelyn; the new Olin Stephens Room also carried some of the overflow. The new facility gives the sailors everything they need. My personal thanks and appreciation go to the members of the Class of '26 who tipped the scales to make it possible. Come and see the new Sailing Pavilion and sail one of the new Tech dinghies!

It's a balmy October Sunday morning at Pigeon Cove with a few sailboats out on the bay, and it stretches the imagination to realize that you will be reading these notes about Christmas time. To all of you, my first holiday greetings as I say "Cheerio" until 1977. — **George Warren Smith**, Secretary, P.O. Box 506, Pigeon Cove, Mass. 01966

27

It looks as if we are going to have a quite respectable turn-out at our 50th Reunion. You'll be getting up-to-date figures from **Dike Arnold** from time to time. Latest count indicates that over 100 hope to take in at least part of the events, and replies are still coming. If you haven't yet replied to Dike's questionnaire, which accompanied the tentative program, there is still time. Write to Dwight C. Arnold, 7 Elkins St., South Boston, Mass. 02127 and tell him your plans. If you haven't yet sent your $10 dues (check payable to "Class of 1927 — M.I.T."), send it along, and add some current notes about what you are doing.

Abraham Mankovich's son, Paul, was drowned in a scuba-diving accident early this year, and I know that the entire class joins me in sympathy. Paul saw world-wide service in the Air Force, receiving many air medals for Viet Nam and Thailand duty, and reached the rank of major. He was only a few months away from promotion to Lieutenant Colonel when his life was so cruelly cut short.

Abe himself has had a notable career, including 37 years as a government chemist. He is listed in *American Men of Science, Who's Who in Engineering,* and *Chemical Who's Who* for his work in chromium plating, spectrographic analysis, and surfactant chemistry, holds ten U.S. patents, and has published some 100 papers in these fields. Since retiring from the Federal Civil Service in 1967, he has been teaching calculus and drafting to local high school students, full time for six years and half-time since 1973.

Charlie Sweet has movies of the 10th and 25th reunions which he is planning to bring to the 50th. . . . **Hank Kurt** is still the yachtsman; he writes that **Joe Burley** has just joined his yacht club. He had recently seen **Larry Coffin** and **Bud Gillies**. Hank expects to be at the Reunion, but Bud's present plans will take him out of the country next June.

When **Biderman T. (Ermie) Du Pont** received his degree, he made two vows to himself: that he would never marry, and that he would never attend a class reunion. He has kept the first vow, but he says, "I am, at this date, sorely tempted to break my second vow. I suspect this weakness is proof of my advancing senility, or perhaps it stems from a fear that not many of you guys will be around to celebrate our 75th or 100th reunions. Whatever the reason or motivation may be, I do hope to attend in 1977."

Jerry Spurr, **Jack Eldert**, **Fred Willcutt**, **Lloyd MacAdam**, **Walter Caunt** and (possibly) and **Joe Yates** expect to attend the Reunion also.

Joe has seen several of our classmates recently, in Florida and in Bartlesville. He tells us that Polly and **Frank Meaker** are planning to come to the reunion; **Ed Damon** may be away on a trip next June; and Kay and **Dan Metzger** will be unable to come.

Two members of the class are seriously ill. **Bill Payne** is in a nursing home in Dayton; Betty would be glad to receive letters from classmates (1500 Ridgeway Road, Dayton, Ohio 45419. . . . **Henry Crowell** has suffered brain damage from arteriosclerosis and is in a hospital; his wife, Pauline, is at 223 W. Gorgas Lane, Philadelphia, Penn. 19119

I regret to report that **Frank Connolly** died on July 2; he had been in the hospital early this year and the May, 1976, notes reported that he was recovering. Frank was active in construction work around San Clemente until just a few years ago. . . . The death of two other classmates has been reported, with no details available. **Henry G. Schmidt** died in Cleveland on June 16, 1976. Mrs. Robert A. Lavers died on April 5, 1975; as an undergraduate, she was **Margaret C. Munson**.

Carl Wies is still in active medical practice in New London, and he writes that he still makes house calls. Much of his time is devoted to the Whale Museum, which he founded. . . . **William A. Zisman**, who recently retired as head of the Naval Research Laboratory's chemical physics lab, is the 1977 winner of the American Chemical Society's $2,000 award in the chemistry of plastics and coatings, sponsored by Borden Foundation, Inc.

Your secretary has now joined the ranks of the unemployed, as of August 30. As this is written, it's been six weeks, and it has been no problem to keep busy. We are about to leave for a couple of weeks in Florida; I am taking one course at the Scarsdale Adult School; I am still devoting considerable time to the Westchester Symphony Orchestra; and I am not yet ready to make any longer-term plans. — **Joseph H. Melhado**, Secretary, 24 Rodney Rd., Scarsdale, N.Y. 10583

28

May we begin by wishing each of you happy holidays and a good year ahead.

Those who attended the Alumni Officers Conference this year were **Homer Burnell**, Frannie and **Jim Donovan**, **Newt Foster**, Dorothy and **Carney Goldberg**, Claudia and **Morey Klegerman**, **Dick Rubin**, Ruth and **Abe Woolf**. We are highly pleased that Homer Burnell was awarded the Bronze Beaver in recognition of his loyal and constructive support of M.I.T. in the Chicago area. If we remember correctly, Homer is the third member of the Class to receive this outstanding honor. Your secretary and Florence had to miss the Conference; we were enjoying our long planned automobile trip through the south part of England in September. It is a land of quiet beauty blended with much history and impressive monuments. During three weeks of travel we drove 1,100 miles visiting palaces, cathedrals, ancient castles, and picturesque sites along the way. As normal tourists, we brought back lots of pictures.

The mail has brought in these brief notes: **Duncan Whittaker** says, "Still enjoying life in Maine — summers on Cliff Island and winters at Falmouth. Georgia and I do some traveling — two years ago to Hong Kong, this year to the Canary Islands and Southern Spain. I have now visited six continents." . . . **Frank Sweeney** says he is still doing consulting work and trying to improve his golf game. . . . **Jim Willett** reports that he has moved from Buzzards Bay, Mass., to nearby Plymouth. . . . From Tokyo, Japan, news of another mini-reunion of '28ers: the family of **Mariano Contreras** had a delightful visit with the **Shikao Ikeharas**. . . . Mary Nichols has had a busy summer in her new home. . . . Judith Miller hopes to visit with some of us soon again in Boston.

Jim Donovan has been doing a magnificient job on the 1928 50-Year Class Gift. Each of us should have the interest, pride, and gratitude to give this project wholehearted support. We are seeking full participation of the Class. It can be done. The Wellesley Class of 1926 achieved 96 per cent participation in their 50-year gift, and we can do as well or better.

The 50th Reunion is one of great events in the life of a class — second, perhaps, only to the 25th. For us this occasion is only a little more than a year away. Even now plans are taking form. As with the 25th and 40th, the 50th will he held on campus. The Institute has already set aside dormitory space for our use. Start early! Decide right now that you are going to be there, mark your calendars, and lay your plans!

We regret deeply to report that **Graydon Smith** died on August 14, 1976. Graydon had his own consulting business and on occasion participated in cooperative programs for graduate students at the Institute. Our condolences have been expressed to his wife, Patricia. Graydon leaves also a daughter Patricia and three sons, Michael, David and Jonathan. — **Walter J. Smith**, Secretary, 37 Dix St., Winchester, Mass. 01890

30

We have a report this month from one of our three ministers, **Bill Alling**, who is living in Huntsville, Ala. Bill says he is partially retired but nevertheless is scheduled to teach courses in math and chemistry at the Westminster Christian Academy in Huntsville this year. During the summer he did quite a bit of substitute preaching, filling in for ministers on vacation.

Haskell Small reports the completion of a very successful telethon for the M.I.T. Alumni Fund in Washington, D.C., last spring. Haskell has been re-elected to the Board of Governors of the National U.S.O. and is President-elect of the Arts Club of Washington. . . . **Irvine E.** (Ted) **Ross** recently concluded 25 years as volunteer choir director at the Memorial Baptist Church in Ft. Wayne, Ind., where he lives and was presented with a new set of golf clubs to celebrate the occasion. He returned to Needham, Mass., in July for a 50th high school reunion, after which he visited **Myron Smith** at Myron's summer home in Sebago Lake, Maine. He also met **George Wadsworth** at a summer theater in New Hampshire during the course of his trip.

George Barker is theoretically retired but still does considerable consulting work. As of last September, he had been working full time for the past four and a half months for his former employer, Van Straaten Chemical Co., in Chicago. He is a chemical consultant specializing in lubricants and surfactants. . . . **Ted Bridge** retired from Catalytic Inc. in Philadelphia in 1973 and moved to Springfield, Mass. He lists as one of his retirement activities running a "personal computer." He recently went to a "personal computer convention" in Atlantic City which was attended by 5,500 people. Sounds like an intriguing hobby. . . .

Hermann Botzow writes from Hinckley, Ohio, that he is "mostly retired," which he explains as "working three days per week — most of the time." He reports having recently seen **Phil Holt**, **Ted Riehl**, and **Jack Bennett**. He had a great time at the 45th reunion at Chatham Bars and would like to attend the 50th at the same location.

Generally speaking, the survival rate of the Class of 1930 has been gratifyingly high. However, we had a bad time last summer when we lost five classmates in about five weeks. Stan Wells died on July 7 (previously reported). . . . **Louis Rubin** died on June 21. Unfortunately, I do not have any information on Louis, other than the fact that he lived in La Jolla, Calif. . . . **Donald McAndrew** died July 15; he worked for Exxon as a chemical engineer for many years, mostly in Baton Rouge, La. He retired in 1962 but stayed busy in many civic activities, as Director of the Community Services Council, President of the Baton Rouge Area Council on Alcoholism, and Vice President of the Capital City Kiwanis Club, among many others. He is survived by his wife, one daughter, and two grandchildren. . . . **Ed Depoyan** died July 21; his sister Rose was kind enough to write. After being graduated from M.I.T., Ed worked for Gillette in Boston, Norton in Worcester, and Carborundum in Niagara Falls doing research on abrasives. In the late 1950s he moved to St. Petersburg, Fla., and started a new career as a teacher. After a stint at Admiral Farragut Academy teaching math and physics, he moved to the Pinellas County Vocational Technical Institute in Florida where he taught until shortly before his death. Ed was an active member of the St. Petersburg M.I.T. Club and a trustee of the Congregational Church. In addition to his sister Rose and wife Olga, he is survived by two other sisters and a brother. . . . Upon **Ralph Scott**'s death on July 28, a resolution was passed by the Board of Directors of the Osborn Engineering Co. of Cleveland, where Ralph worked; he was Chairman of the Board at the time of his retirement in 1974. His wife Marjorie kindly sent me a copy. The resolution characterizes Ralph as "an engineer of high integrity and enthusiasm" who "took deep pride in his profession" and "left a lasting imprint not only upon the structures of his time, but upon the lives of all who knew him." After jobs with Carnegie Steel in Pittsburgh and H.K. Ferguson Co. in Cleveland, Ralph joined Osborn in 1946 as a project engineer and chief structural designer. He participated in the structural design of many projects such as the R.F.K. Stadium, Monticello Bridge, Republic and J & L Steel Mill buildings, Cleveland Lake Front Piers, and many other sports structures, industrial buildings and bridges.

We have a delayed notification of the death of **Harold Fine** on July 30, 1974. For many years Harold had his own consulting firm in Boston, H. D. Fine and Associates, Inc., and lived in Newton Lower Falls. The Fines' older son Steven was a member of the Class of '63 at M.I.T. Harold was past President of the Boston Stein Club.

You have doubtless received the letter from **Ralph Peters** and **Dick Wilson** concerning our 50th Reunion Gift. We are off to a running start by virtue of two substantial gifts during the first year of our effort. I am at liberty to disclose details of the "$60,000 gift" and its source. The sum is an approximate amount and represents the proceeds of a testamentary bequest of the residuary estate of Virginia Hamilton, the widow of our classmate **Holland W.** "Dutch" **Hamilton**. As some of you will remember, Dutch was in the insurance business, associated with Tupman Thurlow Inc. for many years. He retired in September, 1967, and he and Virginia moved to Belen, N. Mex., where he died in 1973. Virginia continued to live in Belen until her death in December, 1975. The pertinent portion of her will reads as follows: "All the rest and residue of my estate, I give, devise and bequeath to Massachusetts Institute of Technology, Cambridge, Massachusetts, for the establishment of fellowships in the name of my beloved husband, Holland W. Hamilton, Class of 1930." It is evident that this bequest illustrates one way in which a relatively modest accumulation of wealth by an alumnus can be used to provide substantial financial help to talented M.I.T. students. We now have about $150,000 already in, and with the matching gift program to help us, we certainly ought to be able to make a respectable showing by 1980. — **Gordon K. Lister**, Secretary, 530 Fifth Ave., New York, N.Y. 10036

31

Ed Worden, our Secretary, is out of the country for a while so it's a good opportunity to write about him for a change. (Notes by **John Swanton**.) Ed and Sally moved from their long-time Connecticut home to Florida during the summer. Sally writes that the movers gave them a really horrendous time, doing all kinds of damage to their furniture but fortunately they had a good repair section for their antiques so it wasn't as bad as it might have been. But because of the mess they couldn't get into their house for three weeks. Then Ed got sick with a fever for two weeks and recovered just before he had to leave for Brazil, for a consulting job. Instead of retiring, as I thought he was doing, he has a base in Sao Paulo, from which he seems to be covering that whole country, besides taking a boat trip on the Amazon.

When he gets home, he and Sally are going to Bermuda for three weeks, then back to Florida. Sally says their new home is really lovely and they were so fortunate to have found it. . . . Their new address is P.O. Box 1241, Mount Dora, Fla. 32757

Louise and I were at our place in Westport, Maine, for the summer as usual. Saw **Bob Leadbetter** briefly at the Annual Bath Marine Museum Outing where his son-in-law concocts his famous lethal punch. Now we're back in Newton but soon starting a drive to California to welcome an 11th grandchild arriving in October. We're flying to New Zealand and Australia, then to New Caledonia where the father of our A.F.S. (American Field Service) "daughter" is Governor, then back via Hawaii. — **John R. Swanton, Jr.**, Assistant Secretary, 27 George St., Newton, Mass. 02158

32

I trust by now you will have received **Don Whiston**'s annual report to all classmates, and resolved to participate in our 45th reunion. At the Alumni Officers Conference held in September, Don told me of a very interesting program of activities for Technology Days, 1977. With this notice and long lead time for planning let's give Don and his committee some real support.

Carroll L. Wilson, Mitsui Professor in Problems of Contemporary Technology at the Sloan School of Management, was the commencement speaker at the Worcester Polytechnic Institute, Worcester, Mass., and received an honorary doctorate in engineering at the exercises there. . . . **George Baker** checked in recently with **John Finnerty** and **Don Whiston** to let them know he was keeping up with their doings and activities.

While in Cambridge at the A.O.C. meeting I learned the shocking news of the sudden passing **Thomas E. Sears, Jr.**, on August 7, 1976. Tom was one of our most active supporters of class activities. He was a member of numerous fraternal and professional organizations, and very active in Scituate, Mass., town affairs. He was president of the Thomas E. Sears, Inc., Insurance Co., and a member of the American Engineers and the Insurance Institute of America, and a past director of the Insurance Brokers Association of Massachusetts.

I also learned that **Irving I. Schell**, Senior Scientist and Director of the Ocean-Atmosphere Research Institute of Cambridge died during July, 1976. Irving was one of the first students in the newly established department of meteorology, and did graduate work at M.I.T., Harvard and abroad. He served as associate meteorologist at the Woods Hole Oceanographic Institute from 1948 to 1960 and as research geologist in Tufts University's geology department from 1954 to 1965. He was the author of many scientific papers and an expert in the field of polar ice research.

The sympathy of the class is extended to the respective wives and families of Tom and Irving. . . . And may I close on a note of hope and optimism by extending to one and all the season's greetings together with a happy and healthy New Year — **John W. Flatley**, Apt. #204, 5100 Dorset Ave., Chevy Chase, Md. 20015

33

Merry Christmas to all from Leona and Ye Scribe. Top billing goes to **Ralph E. Cross**, Cross Co., Fraser, Mich. Ralph sent me a fine letter, and says that his elder son, Ralph, Jr., is managing director of the british plant, which produces mostly for international trade. He received the Queen's Medal, and award for exports, 1974. He also was invited to Buckingham Palace to meet the Queen. Son Dennis, is Assistant Vice President of First Boston Co., of New York City. A daughter lives in Singapore. Ralph has seven and a half grandchildren. He has made two visits to China, representing his British subsidiary (he gets a Ho-Hum when he mentions his U.S. connection). The Chinese are not too happy with our trade attitudes; few have ever heard of Detroit. Earlier this year, Ralph was named "World Trader of the Year" by the World Trade Club of Detroit. He was President of the National Machine Tool Builders

in 1975. The Cross Co. manufactures a custom, specialized machine tool for producing engines in continuous production.

We have received several cards from **Walt Skees**, who lives in the Bahamas, . . . A fine, long letter cames from **Jack Frost Andrews** who writes mostly of his family. Two weddings this year; youngest daughter, Valerie, married Bruce Williams of Philadelphia, and will live there. His wife Jermain's daughter, Jamie, was married in Princeton to Eric Steiner of Dillon, Colo. Jamie lives in Denver, and teaches in Littleton. Eric works for AMEX, Inc., and has a part in the construction of a $5 million molybdenum mine and smelter, near Dillon. Daughter, Gwen, is still in Montreal, and sells magazine advertising. Daughter Gail and her husband, came from Holland for the wedding, bringing Jack's twin granddaughters. Son Johnnie still lives in Leadville, Colo., and is working for Climax Molybdenum. For his part, Jack has labored for years to begin a Central New Jersey M.I.T. Club. The Club is now a reality and Jack is Chairman of the committee to nominate its first slate of officers. Last January, Jack was elected for the second time to a trusteeship of his church, which he must enjoy as much as I did.

Charley Cashman says he retired in 1971 from the Weyerhaeuser Paper Co. and went to law school. He is now practicing law in Fitchburg, specializing in criminal trial work, as he feels more comfortable with criminals. His daughter was graduated in 1966 from the Syracuse University School of Fine Arts, and is married and teaching art in the Fitchburg public schools. Charley's good wife passed away in June, 1975 (of cancer), so now he lives alone with his English setter. He does some bird hunting in Massachusetts, and Vermont (hence the setter), and some surf casting on Cape Cod and Martha's Vineyard, where he caught a 30 lb. striper last year. He tried for salmon on Gaspe last July, fly casting, but had no luck, though he could see the big ones easily. 'Twas always thus. I haven't caught a salmon in 45 years, except for a couple of Grilse, a year or so ago. Charley has seen **Stan Walters** several times, and sees **Roger Congdon** occasionally. Charley retired last June as Chairman of the Fitchburg Board of Zoning; he says he has made enough enemies.

Joel Stevens just sent me photos taken at the last Fiesta, and they are good. I returned three, asking that he identify a few of the classmates so they can appear in the *Review*. Joel and Elizabeth enjoyed Mexico so much they've embarked on a trip to the source, Spain.

I saw **Westy Westaway** and **Courtenay Marshall** and his wife at the Alumni Officers Conference dinner. **Bill Klee** writes that he had every intention of attending the Confence, but was forced to forego the pleasure on account of Peggy's health. She was not up to the stess of the two-day event, so they flew to Buzzards Bay for a more relaxing visit with friends. The Klees are spending about 40 per cent of the year at their home at Hilton Head, S.C., "Sea Pines," where he says "We are in the phone book, and would like to hear from '33ers, for drinking, talking, eating or golf." Bill is involved in work with the University of California, while at Hilton Head. It's funded by the National Science Foundation and deals, via seminars, with the relationship between science and society. The aim is to create curricula for community, high school, junior college, Y.M.C.A., etc. He hopes to persuade nonscientists that they can learn about science to read intelligently and to respond as citizens. Bill says that anyone interested should write him at Box 990, Warren, Ohio, 44482.

Werner Bachli says the best part of his summer vacation was two weeks at the Appalachian Mountain Club's August camp, north of Fryeberg, Me. He met **Mal Masters** there, though he saw little of him as they were both too busy for gossip. Mal was canoe trip leader at Cold River, and Werner was camp leader. Werner lists a few reasons why his women did not go along: bathing in mountain streams, leaky tents, black flies, mosquitos, rising at 6:30a.m., and more. Werner can't understand why I dug a small Panama Canal this summer, 900 ft. long and four to six ft. deep, to house a new plastic water pipe for the home water system. Dang well rocky going, too. Says he, "Surely you don't drink the stuff!" As a matter of fact, we do, though not always straight. Now the man tells us he will be officially retired as of August 1, 1977, from I.G.E. So, next year he can stay longer at the next camp in the Adirondacks. You might recall that Werner spent a lot of time in South America and India for I.G.E., doing nothing, so the company must have decided that he could loaf more cheaply in the Berkshires.

I have a list of about 25 classmates now living permanently in Florida. And we must have half that number spending winters there. I'd like this group to report their Florida addresses so that one of these winters, we can hold a class get-together, somewhere central, for a day and night of good fellowship. We hope that it will be purely social.

I have two Alumni Fund capsules, always welcome. **Bill Reed**, architect, writes that he has moved from San Juan to Sarasota, and enjoys the beautiful little city and retirement. Golly, maybe another vote for my son, Warren S., who's a Florida Senator. . . . **Robert F. Crane**, another architect, has retired from the Architects Collaborative, Inc., of Cambridge. He enjoys retirement, but has returned to work twice as a consultant. Left late July for a survey of the building industry in Algeria.

Only one of ours has left us this time around, but it is an old and dear friend, **Sam Prescott**. Sam passed away September 10 and his sister notified the Alumni Association by letter, which was forwarded to me. Sam was the son of the late Professor Prescott, who was Dean of Science when we were students, and was M.I.T. Class of 1894. Sam was President of the Benjamin Chase Company of Derry, N.H., and lived in Auburn, N.H. He was a Lambda Chi Alpha. He is survived by his wife, Dorothy, a sister, and a brother, Robert Prescott, M.I.T. Class of 1932. Sam will be missed by his fellows in course XV, as well as by many more us. — **Warren J. Henderson**, Secretary, Fort Rock Farm, Exeter, N.H., 03833

34

As I mentioned in the last notes, I had a letter from **George Bull** about a trip to Russia, and it is worth quoting at greater length than space permits. He writes many details; here are some highlights: "In Moscow we went through the Moscow subway — famous for its beautiful stations and great depth, saw the Bolshoi Ballet, visited the Armory Museum and the many domed churches in the Kremlin, shopped in the GUM department store, and stood in line for two hours to see Lenin himself.

"Leningrad is a very western city, and the Summer Palace at Peterhof looks like Bavaria or a small Versailles. The treasures in the Hermitage show a wonderful job of preserving the heritage of the past despite the turmoil the country has gone through. We flew southeast to the Transcausasian area and spent a few days in the old Kingdom of Georgia, now a Soviet Republic. The people were relaxed and friendly. They raise tea which is poured into the tourist at the slightest opportunity. The old buildings are very distinctive and the churches reminders of the fact that Christianity came to this part of Russia many hundreds of years before it came to Europe.

"Central Asian Republics, Uzbek and Tadzhik, had many beautiful mosques and ruins with blue Persian tiling and inscriptions from the Koran. Samarkand was the high spot with its tomb of Tamerlane and its inscription, 'If I should awake, the world would tremble.' Bokhara had more minarets and mosques but no rugs as they are now made in West Pakistan.

"Before returning to Moscow we sampled the vastness of Siberia with a trip to Irkutsk and an overnight stay on the shores of Lake Baikal. It is said to be the deepest lake in the world — that may be, but I would say it is one of the clearest."

On the more mundane side, **Sam Prince**, having retired from the liquor business and moved to East Falmouth on the Cape in 1973, is now active in real estate. He has been named Sales Manager of Holly Point, a private home development in Centerville.

I must record the loss of two more members of the Class. On June 15 **Gordon Glover** died in Hartford. He had spent 39 years working with Pratt and Whitney, retiring in 1974 as Senior Project Engineer. Gordon is survived by his wife Anne, two daughters, and a sister. I also have word of the passing of **William Ragland** in Greenbrae, Calif., but can tell you nothing more about him. To both families, I would extend the sympathy of all their classmates.

And now to catch up with some of the Alumni Fund notes. **B. Russell Franklin**, who is a Cape neighbor, is unnecessarily apologetic when he writes, "Sorry this is so small but am heavily involved in my undergraduate giving. All this will do is help your percentage." The widest participation is just what we hope for. . . . **George Merryweather** says, "I am recycling real property as an associate broker with Beverly-Hanks Realtors in Ashville, N.C., and we have my youngest children, twins — a boy and a girl — who will be 13 and entering eighth grade this fall, with us. I also have four grandchildren." . . . **Joe Drankowski**'s note sounds discouraging: "Unemployed — planning an early retirement."

From **Henry Andrews**, who was elected to the National Academy of Sciences in April, 1975: "Although I am retired from the University of Connecticut, I am now working on a history of paleobotany." . . . **C. Sherman Grove, Jr.**, writes from Virginia, "Am retired but continuing my activities as an engineering consultant." . . . Finally, from **Richard F. Miller**: "Retired from U.S. Steel in 1970 and moved from Pittsburgh, Penn., to Winter Park, Fla."

There are still some more Fund notes plus a letter from **Jim Eder** who was in Peking during the earthquake last July. (We seem to specialize in looking up earthquakes.) They'll be coming along next time.

I might mention we had a good representation at the Alumni Officers Conference in September. Besides myself, there was **George Bull**, **Walter Wise**, **Hank Backenstoss**, and **Jean Raymond**, the latter down from Montreal. He is still his same ebullient self and all wrapped up in a new business — the vacuum deposition of reflecting metals on flexible plastic sheets. From the samples he had, it would seem to have, among other things, great potential in the decorative field. — **Robert M. Franklin**, Secretary, Satucket Rd., Brewster, Mass., 02631; **George G. Bull**, Assistant Secretary, 4601 N. Park Ave., Chevy Chase, Md., 20015

35

More honors for **Walter H. Stockmayer**: he has been elected an Honorary Fellow of Jesus College, Oxford University. This is an honor infrequently accorded by Oxford and adds to Stocky's already impressive list of recognitions. He is currently in his tenth year as the Albert W. Smith Professor of Chemistry at Dartmouth.

The Annual Gold Tournament of the Class of 1935 has run its course, and Bill Bates is Champion for the second consecutive year. All he needs is one more win to be able to retire the President's Trophy. **Ham Dow** was the runner-up, coming back from an opening-round defeat to win the Consolation Flight and get into the finals. The margin of victory was the difference between the course ratings, only 0.6 of a stroke. All in all it was a successful season with 24 '35ers playing 37 matches and seven of the matches being decided by less than a stroke. We could handle another eight players very easily. I hope those of you who like to play golf and have not been in the Class tournaments, or were once and dropped out, will seriously consider giving it a try in 1977 — tempus fugit.

We are happy to learn from Lee Abramowitz, widow of our late classmate **Bill Abramowitz**, that she has married Walter H. Solomon, and they are living at 236 Confederate Circle, Charleston, S. C. She writes with enthusiasm that Charleston is a

beautiful place to live and that her husband is the greatest guy.

These notes are a direct reflection of the lack of correspondence for me to quote. Unless I hear from some of you who have never given me your post-M.I.T. life story, the next issue of the *Review* will report on the results of a coronary angiogram I am having next week and the subsequent surgery sometime in November. So better write now while it's in mind. Happy Holidays. — **Allan Q. Mowatt**, Secretary, 61 Beaumont Ave., Newtonville, Mass. 02160

36

Two more class members announce that they have joined the ranks of the retired: **Bill Hope** writes that he is enjoying retirement very much — "especially with boating and fishing and general puttering around the house, with no pressure or deadlines to meet. However, I'm still consulting for Moore Business Forms (Research Division) and that takes one or two days a week from my loafing and helps to keep my mind in shape." . . . **Harold Nutt** writes that he has retired after 37 years with the U.S. Navy as a civilian engineer. For the last 15 years he was Technical Director at the David Taylor Naval Ship research and development Laboratory in Annapolis. . . . **Doug Cairns** writes that he is retreating from the rigors of a Vermont winter and has joined the trek to

At the Alumni Officers Conference in September at Cambridge your Secretary saw President **Tony Hittl**, **Elliott Robinson**, **Leo Kramer** and **Bill Rousseau**. Bill, who is a graduate member of the class, is serving as Alumni liaison with the Department of Chemical Engineering.

All the best to each and every one of you. — **Alice H. Kimball**, Secretary, P.O. Box 31, West Hartland, Conn. 06091

37

Sidney Mank closed out his construction business in April and in November, 1976 planned moving to Route 626, Box 108A, Washington, Va. 22247. He hopes to farm and possibly handle real estate. . . . **Frank D. Lewis** is still chief engineer of the James Millen Mfg. Co., Malden, Mass. They may have to move due to urban renewal. He is still a member of the International Radio Consultative Committee Study Group VII on dissemination of standard time and frequency. Youngest son, Peter (M.I.T. '75) now has a biology fellowship at Yale.

Lewis R. Reitz, Jr. for the last three years has been an electronics consultant to the motion picture and television industry in the Hollywood area. He writes "too old to get a job and too poor to retire." . . . **Robert C. Uddenberg** reports that after 32 years in aerospace and missiles he left the Boeing Co. and went to Sitka, Alaska, as president of Sheldon Jackson College (a small church-related two-year college). He was there for several years until February, 1975; he returned to Alaska in August, 1975 as Assistant Director for Management at the Naval Arctic Research Laboratory at Barrow. . . . **Sidney Levine** is now Associate Editor of two publications: *Pit & Quarry* and *Modern Concrete*, both published by Pit & Quarry Publications, Chicago, Ill.

William J. McCune, President of Polariod, narrowly escaped being kidnapped on August 12, 1976. The attempt occured at 8 o'clock in the morning. As Bill went to enter the building, two men with covered faces and a shotgun tried to force him into their van. He fought the men off but got hit on the head with the gun. The men fled. Bill was treated at the hospital for minor injuries. He was named vice president of Polaroid in 1967 and president and operating head in 1975. In a recent article in the *Wall Street Journal*, a junior executive was quoted as saying "Don't ever try to arm wrestle him. He's totally competitive — all you have to do is challenge him to anything mental or physical".

Philip D. Becker writes from Waterbury, Conn., that he is still in development in the fastener business. . . . **S. Curtis Powell** became an M.I.T. Professor Emeritus on July 1, 1976 (early retirement). He is now residing in Phoenix, Ariz., and has been elected Chairman of the Arizona Council of Engineering and Scientific Assoc. He received a citation from the American Society of Mechanical Engineering in recognition of his national and regional activities. . . . **E. L. Hobson** "Hobby," President of Aladdin Synergistics, Inc. of Nashville Tenn., writes that in June **Al Busch**, **Chuck Griffith** and his three sons, along with Hobby and his three sons made their annual fishing pilgrimage to Quebec. A wonderful trip, lots of black flies and some fish. He is having great fun building a multinational organization for meal delivery systems. . . . **Mortimer H. Nickerson** has arranged to be in Florida in the winter and Cape Cod in the summer, the best of both worlds. — **Lester M. Klashman**, Assistant Secretary, 198 Maple St., Malden, Mass. 02148; **Robert H. Thorson**, Secretary, 506 Riverside Ave., Medford, Mass. 02155

38

It took 38 years for the Class of 1938 to be recognized for what it is — now, officially, "Illustrious." At the Alumni Officers Conference held in Cambridge last September, **Harold Strauss** was awarded a Bronze Beaver. Also present in Cambridge were the Squire of Boxford, **Ed Hadley**, **Dave Wadleigh**, **Don Severance**, of course, your Secretary, and **Fred Kolb**. Fred was due to depart for Paris the next day to pick up ten loaves of French bread; reservations were on T.W.A., which arranged a strike in his honor. All was saved when the M.I.T. travel group was able to smuggle him on a British Airways Flight.

Speaking of Ed Hadley — Plan to come for Alumni Day. Ed is the Chairman this year, and promises V.I.P. treatment for all classmates.

Curt Torrance was elected a fellow of the American Consulting Engineers Council, the highest honor given a consulting engineer by his peers. Curt is Manager of the Charlotte District Offices of Charles T. Main, Inc., and is current President of the North Carolina Consulting Engineers Council.

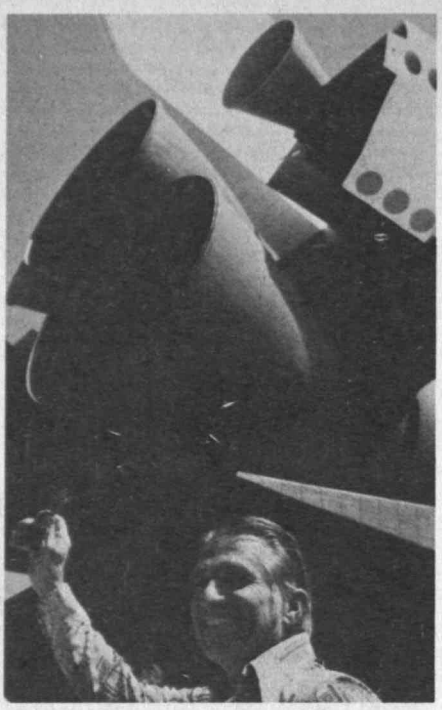
Walter Johnson wrote that he spent several years with Maxwell O. Urbahn Associates in connection with a contract to upgrade all post offices in the northeast area. The job having been completed — witness the present speed of postal deliveries — Walt is now associated with Xenergy, Inc. of Lexington on energy conservation studies. — **A.L. Bruneau, Jr.**, Secretary, Hurdman and Cranstoun, 140 Broadway, New York, N.Y. 10005

39

Ben Howes sent some news. He has spent most of his career working on gas turbines, first with Pratt Whitney and now with Ford, where he is charge of all turbine work at Ford — a 90-man effort. Ben's wife, Anne, has devoted some of her time in the last nine years to hospital volunteer work. One daughter, Priscilla, is 27 and she is on leave from General Motors and working for her M.B.A. at University of Michigan. Her twin, Candace, is at Berkeley working on her Ph.D. in economics. Their third daughter is Peggy, 25, who operates a tutorial center in Bennington, Vt. Their youngest daughter Libby, 21, is in her third year of drama at University of Michigan.

George Cremer invited me to the history-making first "rollout" of the Space Shuttle. The Space Shuttle is designed to fly 100 missions, carrying seven persons and 32 tons of cargo into orbit, and returning 16 tons of cargo to the earth. George Cremer was in the vanguard of the pioneers at Solar Division of International Harvester. He contributed vital services in the design and production of complex beryllium housings and honeycomb sandwich parts used on both Moon and Mars explorations. We also saw the command modules of Apollo XIV, in which Edgar D. Mitchell, '64, flew to and from the moon.

Harold N. Strauss, '38 (right), accepts his 1976 Bronze Beaver Award from Alumni Association President Edward O. Vetter, '42. "For more than two decades he has actively served in a host of M.I.T. activities in the Southern California area while simultaneously giving his time and talent as an officer of the illustrious class of 1938 and a productive worker for the Alumni Fund and Educational Council."



George Cremer, '39, attends the premiere viewing of the Space Shuttle and indicates "where the hot air comes out."

Franklin E. Penn, '40 was awarded the 1976 Bronze Beaver at this year's Alumni Officers' Conference. "For thirty years he has held leadership roles in his class and in the New York Alumni Center; and for over twenty years he has given unstintingly of his time and talents as a thoughtful advisor to the Directors and their staffs.

John Renshaw is concerned about our national security and he has written a 27-page summary of his views, entitled: "Soviet Leaders Have the United States in Deep Trouble — Unless?" Senator McClure of Idaho was so impressed with John's ideas that he called them to the attention of each member of Congress, and he read John's summary into the Congressional Record. Classmates who desire a copy are invited to write John at One Embarcadero Center, Suite 2109, San Francisco, Calif. 94111.

Our 84-man chorus became Champion of the Far Western District which includes 10 per cent of all Barbershoppers in the U.S.A. Our Chorus will be in Philadelphia during July, 1977 to do its doo-wah thing and to compete for the National Championship. Come join us and share a harmony thrill! — **Hal Seykota**, Secretary, 2561 Via Viesta, La Jolla, Calif. 92037

40

Proud Beaver: At this year's Alumni Officers Conference at M.I.T., **Franklin E. Penn** was awarded the 1976 Bronze Beaver. He joins the distinguished **Russell Haden, Jr.** (1972 Beaver) and **James Rumsey** (1975 Beaver) who also serves as a Director of the Association.

From Georgia: Not from Jimmy, but from **Robert Seedlock**, manager of the southern region for Parsons, Brinckerhoff, Quade & Douglas, an answer to one of our random roll calls. Bob is settled now in Atlanta with his wife, Hortense, an accomplished musician, after many years "on the road" in such faraway places as China, Morocco and Korea, serving with the U.S. Army. Bob was named "engineer of the year" for Metro-Atlanta by Georgia's Society of Professional Engineers, citing his military engineering as well as his new role for Parsons, etc. in Georgia.

Executive Suite: **Henry Singleton**, Teledyne Chairman, directs the stratospheric moves of that company, and signals that the conglomerate may soon begin further acquisitions. Teledyne has already acquired substantial amounts of stocks of both Walter Kidde and Co. Henry is a "rara avis alumnus" with three degrees from M.I.T.

Random, Mostly, Roll Call: This issue's roll call beckons to those in other lands: **Pedro A. De Castro**, Puerto Rico; **Henri B. De Cerenville**, Switzerland; **Selahattin M. Engez**, Turkey; **Nicholas N. Ershov**, England; **Carlos F. Graef**, Mexico; **Robert T. Harland**, Canada; **Nelson Hogg**, Canada; and **David. M. Huber**, Netherlands. Send us news of your work and family. If you use small denomination stamps, you shall help a grandchild's collection — **Frank A. Yett**, Secretary, 254 S. Euclid Ave., Pasadena, Calif.

41

Here it is time to write the December class notes and it's only October. As I described in my last notes, our 35th reunion was a great event and if you would like to see how we all looked, **Ed Marden** has arranged for Fay Foto to send you a reunion photo. Send $3.00 to Fay Foto, 201 South Street, Boston, Mass. 02111. I saw Ed at the Alumni Officers Conference in September. Two of your classmates received the Bronze Beaver Award: **C. William Hargens**, Fellow-Franklin Institute, Philadelphia and your Class Secretary. Only two other members of our class, **Reid Weedon** and **Carl Mueller** have received this award.

We have sad news to relate: **Joe Bergantz**, of the State University of New York at Buffalo, and **Franklin W. Kolk**, Vice President of American Airlines, died this past summer. Our condolences to their families.

Other news of classmates: **Howie Samuels** is New York State Finance Chairman for Jimmy Carter. . . . Professor **George Newton** was on the Loch Ness Monster expedition in Scotland. He planned to "install permanent infrared equipment to monitor the lake's surface at night." . . . I talked with **Pete Smolka** who is a partner in the patent attorney firm of Burns, Doane, Swecker and Mathis in Washington, D.C.

The Stamford, Conn., *Advocate* had a feature article on **Nat Owen** who put General Signal Company together and is now Chairman of the Board and Chief Executive Officer. Sales have gone from $20 million to $600 million since its formation.

A note from Ray Stevens, Class of 1917, about **John Lyons**: "It was only three months ago when John Lyons and six other employees of the A. C. Lawrence Co. tannery, faced with being laid off, decided to try to resurrect the company, which its owners had declared dead. The A. C. Lawrence Co. plant, closed on February 28 after 80 years, has been reincarnated as the National Tanning and Trading Corporation." The only aspect of the story I couldn't believe was the caption under the photo which said "white-haired John Lyons."

Bill Baldwin and I met recently in the Pittsburgh airport. Bill is with Pechiney-Ugine-Kuhlmann. His son majored in Chinese and is now in the U.S. Marine Corps. . . . Congratulations are in order for **Ken Roe**, President of Burns and Roe who has just been elected an honorary member of A.S.M.E. This is a major milestone and I'm sure Ken deserves this recognition and honor.

More next time. Don't hesitate to send in news. Merry Christmas and a happy new year. — **Henry Avery**, Secretary, #2863 — 600 Grant St., Pittsburgh, Penn. 15230

42

The most important news this month is that our 35th Reunion is coming. It will be held from Thursday, June 9, through Sunday, June 12. You will soon be hearing from our general chairman **George Schwartz** and his committee about definite plans.

This year's Alumni Officers' Conference was well attended by our class: **Paul Hotte, Warren Loud, Lou Rosenblum, George Schwartz, Geza Neumann** and your secretary were all there. The

meeting was certainly the best I have attended in recent years, particularly because **Ed Vetter** did such a superb job presiding and even more importantly — with wit — over his first A.O.C. as Alumni Association President.

Richard A. Richards tells us that he is still a professor in the Engineering Science and Technology Division of Suffolk County Community College and also Chairman of the Long Island chapter of the American Society of the American Society for Metals. . . . **Charlie Ruckstuhl** is thinking of retirement (whatever that is) next year. He and Muriel take four vacations a year — three weeks in the Caribbean, three weeks at Winnepesaukee, a week in Bermuda and a week on the upper Michigan Pennisula. If that is Charlie's idea of non-retirement, I'll take a piece of the action anytime!

As usual, I'm writing December notes in the middle of October, so best wishes for a Happy and Healthy New Year, particularly to any of you who will send in some news soon! —**Ken Rosett**, Secretary, 191 Albemare Rd., White Plains, N.Y.

43

Gray Trembly, Principal Engineer at Raytheon's Missile Systems Division in Bedford, Mass., wrote, "I have been serving as one of scores of judges at the State Science Fair at M.I.T. for several years; really enjoy meeting some of the bright future engineers." . . . Recent newspaper articles have brought us up to date on Libby and **Bill Post**, who moved to Waterbury Center, Vt., two years ago. Bill is president of the family-owned entity, The Emily Post Institute, and Libby is an author, whose works includes a monthly *Good Housekeeping* magazine column, a nationally syndicated newspaper column, and revisions to *Etiuette*, the famous blue book of social usage first published by Bill's gradmother in 1922. The latest volume, *The New Emily Post's Etiquette* deals with newer social niceties such as showers for unwed mothers, birth announcements for unwed parents, dress for the pregnant bride and sleeping arrangements when daughter arrives home with her bearded roommate.

Although we mentioned in recent class notes about **Ed Epremian** becoming executive director of the National Research Council's Commission on Sociotechnical Systems, we didn't describe the Commission. It is the principal operating agency of the National Academy of Sciences and the National Academy of Engineering. It is responsible for programs concerned with large-scale technological systems that provide goods and services to the public and has a specific charge to study the opportunities and social consequences created by these systems. After such a busy career, Ed is going to be a lot busier.

Class President **Ken Warden** called your secretary recently to say that he's keeping a lookout for a good location for our 35th Reunion, and that he hopes more of the Boston group can meet more often. I was near Ken's place at the Cape in September, but we missed connections, although he visited with **Jim Hoey** that week.

Sad news from New York City came late in September, telling us of **Joe Tankoos**' death on the 20th of that month. He had been very prominent in real estate and hotel ventures, and was well known internationally for charitable and other humane activities. Our class sent condolances to Mrs. Tankoos.

The cooler part of the fall season has set in here in Connecticut, but you can count on me to keep the home fires burning for all of you errant correspondents, wherever you are. I'm still on my honeymoon, so please don't telephone me after nine. — **Richard M. Feingold**, Secretary, 779 Prospect Ave., West Hartford, Conn. 06105

44

The 1976 Alumni Officers Conference of M.I.T. convened at the Institute on September 17. It was important to Melissa and me for it was the first of these meetings for us. We were able to attend the Friday evening and all day Saturday sessions. The Friday evening session at the new Hyatt Regency Hotel, on Memorial Drive in Cambridge — it's worth trying the next time you are in Cambridge — provided us with an opportunity to visit with friends from other classes.

We saw some old time friends of the Class of '44. Stanley Proctor '43, who was with some of us in the service, was there, continuing his devoted service to the alumni, to prospective students and to the Institute. Kemp Maples, '43, who was a special help to the R.O.T.C. bunch under Major Buckingham (and who perhaps ought to be an honorary member of the Class of '44) was there. At least Kemp should be a member of the Shaftees, the semi-official group formalized by **Louis Demarkles** in commemoration of the experiences of the R.O.T.C.—Basic Training — O.C.S. group.

It may help you feel young; it may make you feel old; but if you want to feel that time has stopped, chat a while with Professor Edgerton who manages somehow to be at these functions despite his inimitable schedule that encompasses Jacques Cousteau and the Loch Ness monster.

Following the banquet there was a nostalgic film, the product of an M.I.T. student's fascination with old film clips (*see page A14*).

Bev Tucker writes that a mini-reunion of '44 Dekes took place when the **Trigg Noyes**' came East from Boulder, Colo., for their daughter's graduation and visited with them and the **Jim Eberleys**.

Lenore E. Brooks Naqvi wrote that she is divorced. Her daughter, 24, is a theatrical costume designer; her son, 22, is a musician. Lenore teaches math at Gallaudet College in Washington, D.C., the only liberal arts college for the deaf in the world. She has a moderate hearing loss as the result of illness and medication while living in India between 1951 and 1953.

Norman Beecher, Program Manager, Ocean Processing, Kennecott Copper-Ledgemont Lab, spoke recently on ocean nodule mining before members and guests of the New England Section of the Marine Technology Society.

A dip into our shallow reservoir of news sent to us in July by *Tech Review* reveals that **Stanley I. Skelskie** of Westwood was appointed to the editorial board of the Food, Drug and Cosmetic Division of the American Society for Quality Control. Stan is currently Vice President of Herbert V. Shuster, Inc., a consulting firm, and his primary activity for the firm is as an account executive for a number of drug and cosmetic companies, as a consultant in quality control and management. In the past he was Corporate Technical Director of Freezer Queen, Inc., Buffalo, N.Y., as well as serving at one time as director of research and development for Ocean Spray.

We also note that **William W. Clark** of Pepper Pike, Ohio, was promoted from project manager in research and engineering to manager of process and engineering to manager of process and chemical development at the Standard Oil Co. (Ohio).

Much to our embarrassment, we finally located an order we had received for the Class of 1944 trays and speedily sent them on their way by U.P.S. Shortly thereafter U.P.S. personnel went on strike and now we wonder if they have been received. If you have ordered your tray(s) through us and have not as yet received same, we would appreciate hearing from you about same.

We would like to take this opportunity to wish all of you a most pleasant and memorable holiday season at this time of year. — **Melissa** and **Newton A. Teixeira**, Secretary, 92 Webster Park, West Newton, Mass. 02165

45

Talk about the passage of time! Our last class greeting was Happy Easter — and now we wish you and yours a Merry Christmas and Happy 1977.

It is true that your Secretary has been a wee bit

Edward O. Vetter, '42, Alumni Association President, presents the 1976 Bronze Beaver Award to C. William Hargens, '41 (above): "In more than twenty years as one of the Institute's most influential ambassadors, his deep interest in M.I.T. and his effectiveness in representing it in Philadelphia have immeasurably benefitted countless alumni and the Institute itself."

Henry Avery, '41 (below), receives his 1976 Bronze Beaver Award: "His dedicated interest throughout a quarter of a century in the Institute and its causes, expressed through service to club, Educational Council, and Alumni Fund, has greatly strengthened M.I.T. in Western Pennsylvania."

"As thoughtful and imaginative colleague and leader — a Director of the Association and member and leader of four national committees — his service to fellow alumni and his steadfast commitment to the highest ideals of M.I.T. have been exemplary." So read the citation on the 1976 Bronze Beaver Award of Harl P.Aldrich, '47 (right), presented to him by Alumni Association President Edward O., Vetter, '42.

For Edward Hanley, M.E. '48 (right), "his leadership, enthusiasm and untiring efforts have immeasurably strengthened M.I.T. in Colorado," and thus earned him a 1976 Bronze Beaver Award.

remiss, yet your lack of activity and news has helped his decay; be that as it may, here we go. In early October Johnson & Johnson announced that **David R. Clare**, then Vice Chairman of the Executive Committee, had been elected President and Chairman of the Executive Committee. Congratulations, Dave, and keep up the good work. . . . While on the subject of Phi Gams, it was great to talk with **Tom Stephenson** of Alcoa and Davenport, Iowa, fame during his weekend visit with Lou and **Pete Hickey** in mid-May. As to the Hickeys, Lou advises that their late May-early June cruise between Guadeloupe and Tortilla, B.V.I., was great fun — some 600 miles in 16 days.

Alan Mencher has left government work (scientific attache in London was his last tour) to work independently in consulting and other activities in the New York, Philadelphia and Washington belt. Undoubtedly, Alan will be writing about his government experiences. . . . **Don Lovell** advises that he is engrossed in making evaluations of devices to calibrate long-wave infrared systems. . . . **Jim Speaker** reports that he and Ann traveled to the Far East in 1975 and further, has a trip to South America this past summer. Jim continues with the Calculator Division at Hewlett Packard. . . . **Clemens E. Prokesch** reports that he is practicing Internal Medicine in New London, Conn. . . . **George K. Turner** of San Francisco runs Turner Design — instruments for water pollution study. George spent several weeks in Europe last spring setting up dealers and the like. . . . **Joe Neschleba**, film distribution manager of Chemco Photoproducts in Glen Cove, Long Island, reports son, Michael, '70, presented him and Eleanor with their second grandchild this past year. . . . **P. N. Shamer** continues as Manager of Advanced Naval Programs, RCA Government and Commercial Systems, Moorestown, N.H. . . . **Pedro Vicien** is Associate Professor in Heat Energy at the Engineering School, University of Buenos Aires.

A long overdue (30 years?) note from **Gustav S. Preller** follows: "Upon return to South Africa after graduation in 1945, I joined the African Metals Corporation as their Mineral Technologist. In 1952 I became Manager of Phosphate Development corporation and later their Superintendent of Research. At present I am a Research Metallurgist with the Anglo American Research Laboratories, Johannesburg. My professor and promotor at M.I.T., the late Antoine M. Gaudin, visited South Africa on several occasions when it was my privilege to have many consultations with him." . . . **John W. Morrison** is deeply involved in Prison Education as well as Grievance Committee work for the American Federation of Teachers. John was an American delegate to the Brazilian labor seminar, Trade Unions in the Reconstruction of Society, early last spring.

From the Better Late Than Never department — **George T. Upton** of LTV Aerospace Corp. in Dallas was elected a Fellow of the American Institute of Aeronautics and Astronautics early last year "for his technical innovations and contributions to the aerodynamics and technical development of military aircraft, particularly the A-7 series, F-8 series, and the Tri-Service XC-142A V/STOL." . . . Cutler-Hammer's AIL Division in Melville, N. Y., under the able direction of **Matt Lebenbaum**, was selected to design and manufacture S-B communications equipment for N.A.S.A.'s Space Shuttle. That's it for now; again, Seasons Greetings, and how about some news! — **Clinton H. Springer**, Secretary, P.O. Box 288, New Castle, N. H. 03854

46

May we wish all of you the very best of Christmas Blessings and a very Healthy and Happy New Year.

As I promised in the last notes I am completing the report on the 30th Reunion. The final evening was a dinner dance that included excellent entertainment by a group consisting of the wives of several classmates, and a few class members themselves. Charlotte Schield, wife of **Bill Schield**, was the organizer and leader, and the group sang several specially composed lyrics to the music of known melodies. Space, and to a degree, propriety, prevents us from printing any of the songs.

Don E. Robison writes that they are trying to revise the M.I.T. Club of Tampa and St. Petersburg area. **Don Burke** is one of the directors. . . . Dr. **R. Gliedman** advises that he has moved his office to 77 Quaker Ridge Rd., North Ridge Center, New Rochelle, N.Y., with the office overlooking the Wykagyl Country Club. . . . **S.D. Bitzer** wrote one of the shortest notes I ever received to say he is an independent life insurance agent. . . . **Dan Daley** wrote the second shortest note to say he is professor and head of Department of Aeronautics at U.S.A.F. Academy.

Mrs. **Roberta K. French** writes to advise that she has served two years in the Peace Corps in Iran assigned to set up a hand weaving factory for the Department of Social Welfare. She has now returned to Mexico and is privately developing the cottage industries of spinning and weaving in Oaxaca and the nearby villages. She says it is lots of fun but wishes she has studied textile engineering. She would like to hear from anyone interested in handloomed textiles or hand-spun yarns. . . . **Hugo C. Johnson, Jr.** has joined Dravo Corp. as general development manager for the company's Chemical Plant Div. Hugo obtained his degree in chemical engineering at M.I.T., his master's degree in chemical engineering at Ohio State University and his business administration degree from Wharton School at the University of Pennsylvania.

We must sadly report the death of **James N. Hendel**, who received his degree in aeronautical engineering in 1946. James had graduated from Phillip Exeter in 1939 and served as a Captain in the U.S. Eighth Air force in Europe in World War II. For the past 30 years he was an engineer at Sikorsky Aircraft in Stratford, Conn. He was named manager of Flight Test ngineering and Evaluation just prior to his death on June 4, 1976. . . . Another classmate, Dr. **Bernard J. Haverback**, died at his home in North Hollywood, Calif., on July 28, 1976, following earlier surgery. Bernard had obtained his degree in medicine at Johns Hopkins following his graduation at M.I.T. with a B.S. in aeronautical engineering. — **Russell K. Dostal**, Secretary, 18837 Palm Cir., Cleveland, Ohio 44126

47

Don VanGreenby, Reunion Chariman, reports that the first meeting of the 30th Reunion Committee was held in Cambridge in September. Plans for an exciting reunion on campus are underway. M.I.T. now provides *free* housing accomodations in the dormitories to all reunioning classes and **Virginia Carter Grammer** and **Parker Symmes** will be selecting the site shortly! Tech Night at the Pops and an old-fashioned New England Clambake are just two of the highlights planned for the June 9 to 11 reunion. **Dick Knight** and **Claude Brenner**, Class President, were also present at the meeting. Don and the members of the Committee are enthusiastic and encourage all classmates to make suggestions and to participate in making our 30th Reunion a smashing success!

Unfortunately, this month I find only a few notes from which to draw.

Jim Prigoff has been promoted to Senior Vice President by Consolidated Foods. In this capacity he will be responsible for the apparel and home furnishings group. . . . **Harl Aldrich** was given a citation for the 1976 Bronze Beaver at the Alumni Officers Conference in September. . . . **Fred Brodersen** writes that last year he became Director of Development and Public Relations for the Deaconess Hospital in Cincinnati. This 274-bed acute-care hospital is considered to be one of the nation's finest. It's medical staff, trustees and generous friends lead Fred to feel that his fund raising work is a delightful experience.

It is sad to report the death of **Bruce Dodd** in Jamaica Plain, Mass. He was one of those caught in the last epidemic of polio and had lived with an iron lung for the last 21 years. Our sympathy to the family.

My best for the holiday season. — **Dick O'Donnell**, Secretary, 28516 Lincon, Bay Village, Ohio

48

Graham Sterling has been promoted to Vice President for Planning and Control of Analog Devices, Inc. in Norwood, Mass. Analog Devices is in an excellent position to capitalize on the Microprocessor Revolution as suppliers of equipment for the enormous number of interfaces between microprocessors and the real (analog) world. Graham's oldest son, Arlie, is a senior at M.I.T. majoring in economics. Arlie was a research assistant in the M.I.T. Energy Lab during the past summer.

My son, Larry Billett, graduated Cum Laude from Yale in 1976. Larry is a Market Analyst for T.W.A.'s scheduling group in their Marketing Department under Bill Slattery. My younger son, Cliff, took a year off from Syracuse and worked for six months as a deckhand on a ship carrying 80 passengers in the Bahamas. He also visited Iran for six weeks. This year Cliff is a junior at Syracuse in their school of organization and management. My daughter, Amy, is a sophmore at Yale. Besides her interests in art, history, French and ballroom dancing, she has completed a year each of biology and chemistry and is taking physics and organic chemistry.

Sam Labate has been elected chairman of the Board of Bolt, Beranek and Newman. . . . **James Orr** was elected to the Board of Trustees of the American Group Practice Association which represents over 430 medical clinics. . . . **Fred Dunmire** has a new assignment at Grumman as Director of Financial Operations, Business Development Department. Fred is a governor at Centerport Yacht Club. . . . **John R. Kearney** has been named Manager of Melting Services Department at Corning Glass Works. John is responsible for glass melting operations in Corning's domestic and international facilities.

Robert Ferens, Professor of Architecture of the University of Oregon, is teaching a seminar on "African Building and Planning" and with five Africans in a class of 22, they have some heated discussions. Robert's Fulbright to Nigeria fell through this year. . . . **J.P. Kourkene** is trying to get his master's in civil engineering from M.I.T. In May, he was waiting to hear from Carnegie Tech about a faculty position teaching post-tensioning of structures. . . . **I.L. Lebow** took a leave of absence from M.I.T. Lincoln Laboratory to go to Washington as Chief Scientist and Associate Director, Technology of the Defense Communications Agency. . . . **Ed Mack** is still working as an adhesives chemist. Ed and his wife, Elizabeth, have moved into a new house with their 8-year-old son. . . . **Walter Chaiko** has completed three years with Ingersoll-Rand. Walter was recently appointed as new Venture Manager to commercialize a new proprietary product for mines.

Norm Kreisman, after many years in Washington, D.C., wrote and said nothing about himself, his lovely wife, Gloria, or his great kids. He still feels that I am siphoning off his contributions to the Alumni Fund by using an elaborate conspiracy too complicated to describe or understand. Norm has not changed in the 29 years since we double-dated and shared his car. I'll never forget a trip from Scarsdale, N.Y., to Cambridge on a rainy night. I rode in the partially closed rumble seat which was kept "open" for oxygen with a piece of blanket. When I awakened in Cambridge, I thought I had made it to the next world until a few breaths of outside air clearned my lungs of exhaust fumes.

John Juechter married Jeanne Johnson in April of 1975. In March of 1976, they moved to the island of Jamestown, R.I., in Narragansett Bay. John has his office in their home. . . . **John K. Crane** was awarded a certificate as an outstanding Board Member for 1975-76 from the Illinois Society of Professional Engineers. John was appointed to the Professional Engineering Examining Committee of the Illinois Department of Registration and Education. . . . **Deal L. Axene** retired from active duty in the Navy nearly two years ago. Dean joined the Pensacola Division of Westinghouse as Manager of International Engineering. Dean's division designs and manufactures reactor internalf for commercial nuclear power plants of the pressurized water type.

Raymond Rogers was recently elected President of the Polymer Corporation. . . . **Gene Purdum** has two sons in college and both are planning careers other than engineering. . . . The third generation of Stutmans is at M.I.T. Dr. **Leonard Stutman**'s eldest son, Peter Steve Stutman, is a graduate student at Tech. . . . **Alfred Bett** is retired from the Navy in September, 1975, and is now working in Washington, D.C., for Sperry Univac.

The Alumni Association notified me that three 1948 class members with graduate degrees have died during the past year. On behalf of our class, I express our sympathy to the families of **Er Chun Ho** of Newport Beach, Calif.; Commander **Harry M. Simpson** of Valley Center, Calif.; and Colonel **Arnold R. Hull** of Washington, D.C. — **S. Martin Billett**, Secretary, 16 Greenwood Ave., Barrington, R.I. 02806

49

Paul Weamer, Class President, leads off this month: "We Weamers have moved from Needham to Madison, Wis. I am with the Carnes Co. in nearby Verona — still fan business, however. Come see us when you are in Chicago — we are only 150 miles northwest." In this year's Class President's letter, Paul reports that our first "Class of 1949 Visiting Professor," Robert S. Morison, was so well received at the Institute during his first year that he was asked to stay for another period. Unless otherwise designated, all class contributions to the Alumni Fund will be credited to the "Class of 1949 Visiting Professor Fund" to increase the effectiveness of our continuing gift to M.I.T. In addition, this year only, an anonymous alumnus has offered to match any *increase* in Alumni Fund contributions, from a minimum of $25 to a maximum of $1,000. So there you are, classmates, make that long-promised increase in giving to M.I.T. this year and double its effectiveness. And don't forget to add a news note to yours truly on the Alumni Fund envelope.

Robert Griggs reports speaking at a seminar in early August at Northern Arizona State University in Flagstaff, sponsored by the Flagstaff Institute. The subject was tandem manufacturing operations in El Salvador and Puerto Rico which can profit from exemptions of income taxes and custom duties.

Harold E. Keene, Jr., died on August 21 in Nashua, N.H., at the age of 47. He was the Marketing Manager for the Pulp and Paper Division of Ingersoll Rand Company. He had been a member of the Paper Industry Management Association and served on the Engineering Committee of TAPPI, the technical association for the pulp and paper industry. He leaves his wife, Patricia, and two daughters, Leslie Ann and Janice Elizabeth. Our condolences to his family.

On a happier note, **Paul G. Miller**, President and Chief Operating Officer of Commercial Credit Co., the $4 billion financial and insurance services subsidiary of Control Data Corp., has been appointed to succeed Chairman John M. Sheehan as the Company's Chief Executive Officer, effective January 1, 1977. Paul was named President of the Baltimore-based Commercial Credit in 1975 after directing the computerrelated marketing efforts of Control Data Corp. for five years. He is a native of Louisville, Ky., and served as a naval officer for 11 years before he started his business career in 1957. He holds degrees from the U.S. Naval Academy and Purdue University, in addition to M.I.T. . . . **Francis H. Sayles**, Research Civil Engineer at the U.S. Army Cold Regions Research and Engineering Laboratory, is one of two men spending two months working with the staff of the U.S.S.R. Permafrost Institute in Siberia as part of an exchange program established through the U.S. and Soviet Academies of Sciences. The two-man team will visit research institutes, field stations, and construction sites to investigate Soviet reserch in permafrost and applications to practical engineering construction on permafrost. Emphasis will be on the construction of hydro-structures in permafrost areas.

Clinton O. Chichester, Vice President for Science of the Nutrition Foundation and Professor of Food and Resource Chemistry at the University of Rhode Island, is the recipient of the 1976 International Award of the Institute of Food Technologists for his outstanding efforts to promote the international exchange of ideas and understanding in the field of food technology. After his S.B. in chemical engineering from M.I.T., Dr. Chichester moved to Berkeley, where he received an M.S. degree in food science in 1951 and a Ph.D. in agricultural chemistry in 1954. He then joined the faculty of the University of California at Davis and in 1967 became Chairman of its Department of Food Science and Technology. In 1970, he became Director of International Food Programs at the University of Rhode Island's International Center for Marine Resource Development and also Professor of Food and Resource Chemistry. In 1972 he was named to his posts at the Nutrition Foundation, retaining his assignments at Rhode Island. He has received honors for his international work, particularly that dealing with the nutrition of children. He helped establish a research program in Chile to develop a socially-acceptable infant food to solve problems of malnourishment, for which Chile presented him the highest award a noncitizen can receive. Czechoslovakia has similarly honored him for work in the nutrition of children, as have numerous scientific and professional societies.

Many or most of you will have heard of the Greenpeace Foundation. For eight years now, its been intercepting whaling vessels in the Pacific and attempting to move in small boats (Zodiaks) between the whales and the harpoon guns. This year, the vessel they used, the *James Bay* renamed the *Greenpeace*, was chartered to the Foundation by a classmate, **Charles W. (Carlos) Davis**. It is the first high-speed, high-performance vessel used by the Foundation, a 152-feet post-war Canadian minesweeper, 400 tons, with 177 tons of structural aluminum. Unlike previous years, Greenpeace expects to be able to keep up with the whaling fleet for extended periods of time. "If Russia and Japan decide to attempt to carry on whaling any longer, they'll have to do it over our dead bodies."

With some trepidation Sonya and I have agreed to become Chairmen of our 30th Reunion, now only two-and-a-half years away. Both **Harry Lambe** and **Stan Margolin** have sworn blood oaths to help as required. Our immediate problems are to organize a committee (volunteers are sought) and to develop some overall policy guidelines: on campus, off campus, or both; if off campus, local (Cape Code, Berkshires, New Hampshire, Maine) or remote (Bermuda, Caribbean, Mexico, Hawaii, ???). We will try to send a questionnaire to the class when we have some alternatives to test. In the meantime, please write, visit, or telephone if you have any ideas or suggestions to contribute. — **Frank T. Hulswit**, Secretary, 77 Temple Rd., Concord, Mass., 01742

50

John H. Litchfield has been appointed manager of bioengineering and health sciences research at Battelle Columbus Laboratories. He is responsible for research in the areas of food science and technology, enzymology, biomedical engineering and health sciences, applied microbiology, and biotechnology. He joined the Battelle staff in 1960. Dr. Litchfield is a fellow of the American Association for the Advancement of Science, American Academy of Microbiology, the American Institute of Chemists, the American Public Health Association, and the Royal Society of Health (Great Britain). He is also a member and is one the executive committee of the Council of the Institute of Food Technologists, and is the past president of the Society for Industrial Microbiology.

Norman B. Champ, Jr. was recently elected Democratic Committeeman in Clayton Township, St. Louis County, Missouri. This post calls for

involvement with politics in the township and county level and Norm is quite pleased at having been elected. . . . On August 27, Corning Glass Works of New York announced the following appointments: **Donald E. McGuire** to manager of manufacturing, Electrical Products Division. Don joined Corning in 1955; and **Charles J. Lucy** to technical manager of telecommunication products Corning Electronics. Charlie joined Corning in 1952.

Our apologies to **Mauricio Casanova Bszan**. It seems we reported out-dated information on him in the May issue of *Technology Review*. To set the record straight, Mauricio is and has been engaged in several professional areas, such as gas turbines, steam power stations, diesel electric plants and the engineering of pumping and water supply systems. He has engineered the consulting service in all of the above fields. Also, Mauricio was chairman of the First Venezuelan Symposium of Gas Turbines which took place in Caracas in April of this year.

The American Institute of Aeronautics and Astronautics of New York City, on July 14, announced the presentation of the Air Breathing Propulsion Award to **Frederick T. Rall, Jr.**, who is technical director, United States Air Force, Aeronautical Systems Division. The award is presented for "meritorious accomplishment in the science or art of air-breathing propulsion, including turbomachinery or any other technical approach dependent upon atmospheric air to develop thrust or other aerodynamic forces for propulsion or other purposes for aircraft or other vehicles in the atmosphere or on land or sea." Fred is recognized for his management and guidance of the F-15/F100 weapon system from conception to operational service. He is also known for his engineering contributions to the F-111 Tactical Fighter and the B-70 bomber, and for his Air Force work as a specialist on all internal aerodynamics problems.

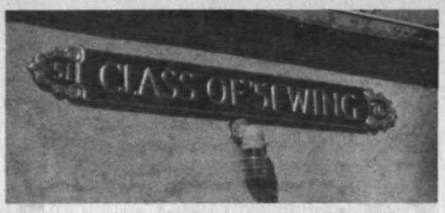
Donald A. Harnsberger has now been allocated an apartment in Moscow, so will finally be moving there with his family (after communting from Dusseldorf for a year and a half). Don is working as U.S.S.R. operations manager for Cooper Industries, Inc. mostly in connection with expansion of the natural gas pipeline network in the U.S.S.R. — **John T. McKenna**, Secretary, 2 Francis Kelley Rd., Bedford, Mass. 01730

51

HOLIDAY GREETINGS!

You will be pleased to know that our class received a Presidential Citation at the alumni Officers Conference in September, 1976. The Class of 1951 has an unsurpassed record of Institute support. This class has always been unique. As undergraduates, 1951 won two Field Days in succession, was innovator of the largest campus celebrations on record, and even accumulated the largest undergraduate deficit of its time. Since graduation, the class has established the all-time records for attendance for its 5th, 10th, 15th, 20th and now 25th reunions. Over 250 classmates are officers in all areas of alumni activities from the Alumni Fund to members of the M.I.T. Corporation. The class has now added its name to its first M.I.T. facility, in part the result of our record 25th reunion gift.

Peter Darin, Vice President and Director of Smith, Hinchman & Grylls Associates, Inc., has been elected State Director of the Michigan Society of Professional Engineers. Peter is also a member of the Executive Board, Detroit area Boy Scouts and Chairman of the local school board in Bloomfield Hills, Mich. . . . **Evan Evans** is Vice President of United Refining Co. in Warren, Penn. . . . **George Field** is Director of the Center for Astrophysics and Professor of Astronomy at Harvard. George's activities include planning a space telescope, a 2.4-metric optical/UV diffraction-limited telescopt to orbit in 1983 with N.A.S.A. sponsorship; planning an Institute to operate it on behalf of scientific community; and also, cultivating his garden, hiking, and swimming in the cold stream of Bath, N.H.



The above quarterboard with gold-leafed letters now graces the west wing of the Sailing Pavilion. Funds for renovation of this wing were provided by the Class of '51 as part of their 25-year gift to M.I.T.

William Hazlett, Commander U.S.N.R., is Project Engineer for the Naval Air Development Center, Warminster, Penn., and is Director of the Upper Black Eddy Civil Defense, and with American Federation of Government Employees Union. . . . **Robert Kress** is Director of Advanced Concepts at Grumman Aerospace. Bob is also active in A.I.A.A., A.H.S., N.A.R.P.U., Radio Controlled Model Aircraft, and plays golf. . . . **Roy Sachs**, of the University of California, Davis, highlighted his 25th Reunion with a memorable workout in an eight-oared shell with other '51 crewmen. The former crew members were royally welcomed by The Boat Club and the M.I.T. Athletic Association. **Art Schein** also took time out from his tennis and skiing to row on the Charles with the '51 crewmen. . . . **Roy Weinstein**, now Chairman of the Physics Department, Northeastern University, is engaged in elementary particle physics research, and was elected Town Meeting Member in Lexington, Mass. Roy and Janet Weinstein are the proud parents of Lee who entered M.I.T., Class of '80, this fall.

Maria Azzarone Bentel was elected to the College of Fellows of the American Institute of Architects, the highest honor the Institute confers. . . . **Frank Davis**, Colonel U.S. Army, was appointed Commander of the School Brigade, Fort Gordon, Ga. . . . **Charles Ellis**, Vice President of Boeing Vertol Co., was elected President of the American Helicopter Society. Charles has been involved in the aircraft industry for over 27 years, and is active in the American Institute of Aeronautics and Astronautics, U.S. Army Advisory Panel, Sigma Xi, and the Joint Airport Zoning Board, and the Philadelphia International Airport. Charles and Madaleen live in Newtown Square, Penn. . . . **Bill Krampert**, his wife Jane, daughters Diana and Patty, and son, Peter, realized a backpacker's dream by hiking the 90-mile length of Bridger Wilderness in Wyoming. . . . **Myron Lecar** is on sabbatical from the Center for Astrophysics, Cambridge, Mass., and will be studying at the Hebrew University and TelAviv University in Israel and Cambridge University in England. . . . **John M. Luger** is a Research Analyst with E.F. Hutton & Co.

Stan Marcewicz climbed to the summit of the Matterhorn last August "as part of the unique class spirit, the 25th M.I.T. Reunion celebration and to fulfill a long dream." . . . **Gordon Powell**, Professor of Metallurgical Engineering at Ohio State's College of Engineering, participated last summer in a special research-in-industry project at Palo Alto Laboratories of Lockheed Missiles & Space. . . . **Barbara and Jay Rosenfield** did such a fine job at our 25th Class Reunion that they needed a vacation. Their August vacation was two weeks of hard intellectual work and thought at the Dartmouth Alumni College, studying "Disconnections: Changing Relationships in American Life."

Please continue sending us information for the class notes. We wish all of you a most successful, peaceful, and rewarding year in 1977. — **Sam Rubinovitz**, Secretary, 3 Bowsar Rd., Lexington, Mass. 02173; **Paul Grady**, Assistant Secretary, 16 Brook Ln., Westport, Conn. 06880

52

There are several newspaper clippings of interest this month. **Donald W. Coakley** has been appointed controller of the Hamilton Standard division of United Technologies Corp. Don joined Hamilton Standard as a test engineer in 1952 and has held several posts, including those of manager, contracts administration, contracts and programs manager of aircraft systems department, and division assistant controller. In addition to his M.I.T. degree, he holds an M.B.A. from Western New England College. Don lives in Simsbury, Conn. . . . **Henry J. Nardone** is now acting manager of the Quonset Point facility of General Dynamics-Electric Boat Division. Mr. Nardone received his degree from M.I.T. in naval engineering. He joined Electric Boat Company in 1955 and has held several key positions in engineering and design, among them overhaul manager for the *U.S.S. Nautilus*. He is a native of Westerly, R.I., a member of the state Board of Regents for Education and a trustee of the Westerly Hospital. . . . The *Acton Minute Man* of Acton, Mass. reports that Colonel **Garvin McCrudy** was recently honored at a special award ceremony at Hanscom Air Force Base. He received the Distinguished Service Medal for his role as air attache in Vietnam, in planning and directing the airlift of 29,000 tons of rice to Cambodia, the evacuation of 1,400 orphans from Vietnam, and most significantly, the emergency air evacuation of U.S. nationals and Vietnamese from Saigon. Colonel McCurdy is the director of the Over-The-Horizon Backscatter radar program at Hanscom A.F.B.

Stephen J. Kline, Professor of Mechanical Engineering at Stanford University, received the Fluids Engineering Award of A.S.M.E. last December for general contributions to the field. . . . **William M. Rogers** has moved to Alameda, Calif., where he is Sales Engineer for Engelhard Industries. . . . **R. Blair Turner** and his wife recently visited M.I.T. and stayed in the Graduate House, (Ashdown House). . . . M.I.T. has cited **Joe F. Moore**, President of Bonner & Moore Association, Inc. of Houston, Tex., for the 1976 Bronze Beaver Award.

Corning Glass Works, Corning, N.Y., announced in July the appointment of **Rodney I. Frost** of Powderhouse Rd. in Corning, N.Y., as manager of mechanical product development. Mr. Frost joined Corning in 1952 and since 1975 has been manager of ceramic process development. . . . **Wesley J. Haywood, Jr.**, staff scientist at Raytheon Co., Missile Systems Division suffered a heart attack and has been unable to work for the past year. I'm sure you will all join me in wishing Wes a successful recovery. . . . **Hal Larson** has recently moved from Maryland to Colorado and is now living on base at the Air Force Academy. He is assigned as the Dental Surgeon for the Department of Defense Medical Examination Review Board there.

Preparations for the 25th Reunion for the class of 1952 are receiving an enthusiastic response. The initial count, showed that 65 members of the class responded with class dues. First indications are that at least 129 classmates and family members will attend. **Arnie Kramer** led a committee meeting on September 15 at **Sandy Kaplan**'s home in Newton, Mass., outlining of the program for the reunion: the traditional Pops concert on Thursday night, June 9, Technology Day on Friday the 10th, clam bake on Saturday and farewell brunch on Sunday. Other highlights of the occasion will be a reception at the President's house, an evening banquet on Technology Day, and an informal banquet Saturday evening. During all the adult activities there will be a children's program spanning four different age brackets. As plans become more definite, additional mailings will be made to better define the activities.

Come and see your old classmates and renew acquaintances with the campus as it now is — **Arthur S. Turner**, Secretary, 175 Lowell St., Carlisle, Mass; **Richard F. Lacey**, Assistant Secretary, 2340 Cowper St., Palo Alto, Calif.

53

Not much news in the mailbag, so I'll report on what there is and make the rest up.

John Batter wrote that he is resigning as our Class President; God only knows what happens now or, more importantly, how that will affect our forthcoming 25th Reunion. Hopefully, some of you in the Boston area will take whatever steps are necessary to see that class affairs and reunion activities stay on track. . . . **Jim Fenske** reports that he has spent the last four years in Hawaii as the Avco Everett Research Labsratory's Director of the A.R.P.A. Maui Optical Station, an observatory located atop a 10,000-foot dormant volcano. He and his family thoroughly enjoyed life in the Islands, though they are returning (or have returned) to the Boston area; they have a daughter at Goucher and a son just starting at Lafayette. . . . Received a long, long letter from **Fred Brecher** (whose nephew, by chance, was a student of mine here at Carnegie-Mellon University); he now is a principal in the Philadelphia-based architectural firm of Geddes, Brecher, Quails, and Cunningham and heads up the Structural Department. He keeps busy — aside from work — as a designer and fabricator of fine jewelry, as a mister fix-it, as a member of the Board of Directors of his synagogue, and so forth. His family ranges from age four to 17, the oldest two being girls and the youngest two being boys. Fred also brought me up to date on three long-lost classmates: **Frank Turcotte**, **Ralph Anglin**, and **Jack Dunnous**. About two years ago, Frank was transferred to the Philadelphia office of Turner Construction Co. and is living near New Brunswick, N.J.; he is a purchasing engineer, has a son in the Air Force and several other children. Ralph Anglin is a partner in a Philadelphia design-build contracting firm, and Jack Dunnous has a consulting business for developing materials processing and handling systems.

Now, "blurbs" from news releases: **Richard Kosiba** recently was promoted by Babcok & Wilcox and named Geschaftsfuhrer (manager?) of Babcok Brown Boveri Reaktor; he will relocate in Manheim, Germany, from Lynchburg, Va. He joined B&W in 1957 and prior to this appointment was Senior Technical Consultant to the Vice-President of the firm's Nuclear Power Generation Division. . . . **Harry Allan** recently switched academic posts, changing from Dean of the School of Management at Syracuse University to Provost at Northeastern University. "Along the way" (my words), he was an Army veteran, practiced law, and was Professor in the School of Business Administration at the University of Massachusetts. . . . The Class of 53's Nobel Laureate (how many M.I.T. Classes can make that statement?) — **Robert Schrieffer** — has won yet another honor: the 1976 John Ericsson Medal of the American Society of Swedish Engineers in recognition of his outstanding scientific contributions, especially in the field of solid-state physics. Bob, along with Bardeen and Cooper, was awarded the 1972 Nobel Prize for Physics, based on their work on the theory of superconductivity. I will not recount the long list of other distinguished honors received by Bob, but will simply say that he now is the Mary Amanda Wood Professor of Physics at the University of Pennsylvania, having previously taught at the University of Chicago and the University of Illinois. . . . Our good friend **Paul Shepherd** received M.I.T.'s Bronze Beaver this fall; the citation read, "By his consistent, far-sighted leadership and enthusiastic support he has been a constant source of strength to M.I.T. and an inspiration to his fellow alumni in Northern California." (Apparently M.I.T. forgot that Paul also did the same for his classmates while he served as our Class President for five years.). . . . Finally, I am sorry to report that **Werner Frank**'s son notified the Alumni Association of his father's death on July 22. Should any of you have more details I will be happy to share them with our class.

Please write; I'm lonely for news! — **Martin Wohl**, Secretary, 7520 Carriage Ln., Pittsburgh, Penn. 15221

54

Now that the temperatures are dropping and heating bills rising, it may be time to contact our classmate, **Feliz Rapp** of Marlboro, Mass. Feliz is producing a "do-it-yourself" solar heating system that includes a unique method of circulating heated air. We wonder if solar energy is being considered by **Mike Deskey** as resident architect on a new basic science complex for the Medical College of Wisconsin in Milwaukee.

Wally Boquist, still traveling, recently dined with **Bob Anslow** out in sunny California. Topic of conversation? Our 25th Reunion, of course! How can we make attendance easy? How about a charter flight from the West Coast, for example? Any ideas from you?

New positions: **John Giancola**, Director of Aeromechanics, Headquarters Air Force Systems Command, Andrews AFB, Md.; **George Becher**, Director of Corporate Engineering, American Pad and Paper Company, Holyoke, Mass.; **William C. Missimer**, Senior Vice President, Government Products Division, Pratt and Whitney Aircraft Group, West Palm Beach, Fla.; **Robert M. Van Meter, Jr.**, faculty at Marist College, Poughkeepsie, N.Y. . . . **Paul Gray** has been elected Chairman of the Board of Trustees of Wheaton College, Norton, Mass., and **Alex Dreyfoos, Jr.**, to membership in the Young President's Organization. Alex, you may recall, is President, Chairman of the Board, and majority stockholder of Photo Electronics Corp., West Palm Beach, Fla.

Ray Mintz just returned from a trip to Hong Kong where he spoke on electronic detection and surveillance equipment to a conference of senior customs officials from Southeast Asian Countries. . . . Dr. **Philip Rane** is currently practicing radiology, nuclear medicine, and ultrasound as a Partner in North Shore Radiological Associates, Inc.; he is also Vice President of the Wakefield (Mass.) Office Corp. . . . **Ron McKay**'s son, Ken, entered the School of Foreign Service at Georgetown University this fall.

We were saddened to learn that **Nicholas Philip** died of cancer last April.

Now, based upon your responses to our questionaire — **Perry Smoot** lives up the street in Wayland, Mass., at the Army Materials and Mechanics Research Center in Watertown, Mass., working on research to measure microshrink in nickel-base superalloys used in turbine component castings. If that has anything to do with turbines in airplanes, best of luck, Perry. We fly a lot and don't like to think of our turbines shrinking at 30,000 feet.

On Patriots' Day, Perry had a super experience: he mustered at 3 a.m. on the Sudbury Common and marched with other militia to the North Bridge in Concord. It was an extraordinary and impressive experience to re-enact the march with 450 fellow townsmen. We have talked to others about their participation in these re-enactments and it is truly an inspiring experience. Perry's son Frank has done well in school and is now contemplating M.I.T.

Peter Felsenthal has an 18-year-old freshman at the Old Diggings; he also has a 20-year-old at the Museum School at Tufts and 15and 7-year-olds at local schools. Pete runs a small manufacturing business, Exunet Corp., which is in the education field.

John Bradshaw is in Roanoke, Va., suh, where he is one of 11 partners in Hayes, Seay, Mattern, and Mattern. They have offices in Washington, Richmond, Virginia Beach, and Roanoke.

Our very respected colleague, **Dave Wones**, is not too far away from John in Bethesda, Md. He lives on Bulls Run Parkway, which for Dave sounds about right. He is working on problems of geology of coastal Maine (from Washington?), mineralogy related to geothermal energy, and uranium-thorium resources. We believe all that is rock hound spelled backwards! Dave is learning rock climbing from his 16-year-old son Ed and recently did a three pitch, 400-foot climb.

The indomitable **Dick Hayes** is out to set the pace for us harried trotters in the industrial rat race. Dick is now Vice President, Advanced Busi-

Joe F. Moore, '52 (above), receives his 1976 Bronze Beaver Award, on which is inscribed: "As a competant worker and dedicated leader, Director of the Association, member of the Club Advisory Board, and leader of the M.I.T. Clubs of Houston and South Texas, and in numerous Alumni Fund and Leadership Campaign capacities, his service to the Institute has been extraordinary."

Receiving his Bronze Beaver Award From Edward O. Vetter, '42, Alumni Association President, Paul P. Shepard, '53 (at right in lower photo) was thus acknowledged: "By his consistent, far-sighted leadership and enthusiastic support he has been a constant source of strength to M.I.T. and inspiration to his fellow alumni in Northern California."

Kevin G. Woelflein, '54, who graduated from M.I.T. in chemical engineering, is now presiding over a complex, multinational banking enterprise whose Board room "may be the only private enterprise in the world that has three simultaneous-translation booths for English, Arabic, and French," says the *New York Times*. Mr. Woelflein is President of the new UBAF Arab American Bank, sponsored by a consortium of 26 Arab banking and financial institutions, three French banks, and four American banks — the first time large American banks have joined with foreign financial institutions in this way. It's a "key funnel" American corporations looking into the Middle East; and to emphasize its special role, UBAF is the only financial institution in the U.S. that makes a market in the major Arab nations' currencies. (Photo: Don Hogan Charles from the *New York Times*)

How a Chemical Engineer Turned Banker Runs an Arab-American Financial Link

When a consortium of 11 Arab banks, the Union de Banques Arabes et Francaises and several of its affiliates, and four American banking companies wanted to open the UBAF Arab American Bank in New York, they turned to an M.I.T. chemical engineering alumnus to be chief operating officer. He's Kevin J. Woelflein, '54, who became President of UBAF Arab American Bank early in 1976 after successfully opening a Tokyo branch for the First National Bank of Chicago.

In his new job, says Mr. Woelflein, he'll be manning a kind of revolving door through which Arab and American interests will pass while making investments in each other's countries. It's the first bank in the U.S. with a predominance of Arab ownership.

Mr. Woelflein told Ann Crittenden of the *New York Times* last summer that UBAF's biggest asset is its backers, a who's who of Middle Eastern finance; every Arab country is represented. After talking with Mr. Woelflein and officials of the New York State Banking Department, Ms. Crittenden concluded that UBAF will be "a key funnel for Arab investment in the U.S.," with its staff acting as advisers and providing management services. At he same time, Mr. Woelflein told her that UBAF will "act as a window for American corporations looking into the Middle East," finding them advisers and introducing them into the Arab community it represents.

This multinational role, and its international backing, are the bank's greatest strength, Ms. Crittenden was told; but they're also a hazard, Mr. Woelflein admitted to her — one instance of this is when the bank has to decide how to allocate credit among demands from the many different countries it represents. — *J.M.*

ness Concepts for Xerox. He likes Rochester very much. Dick has three children, and if you get near Pittsford, N.Y., give him a call. But don't call him if your Xerox jams; that doesn't come under advanced concepts.

Hey, Dick, move over: here comes **John Zvara**. He is President and Chairman of the Board of Aerospace Systems, Inc., Burlington, Mass.

Now a word or three about some of our non-U.S.A. classmates. **Harry Faulkner** is in Djurgardsvagen, Stockholm, Sweden. But all he wrote was his name and address. **Knut Berge** is in Skjoldtun, Norway, where he has a marine engineering consultant firm specializing in very large and ultra large tankers. **Herb Lee** is in Agincourt, Ontario, Canada, where he is a standards engineer at the Canadian Standards Association. He is married to a delightful Danish girl Jytte Wester Blane, and they have a daughter, Helle, now 3. Herb obtained his M.Sc. at Columbia in 1955 and also picked up a similar degree in food technology in 1958. He was in plastics in Jamaica from 1960 to 1971, before migrating to Canada.

Meanwhile, **Frederic L. Holmes** is nearby, in London, Ontario, where is Chairman of the Department of History of Medicine and Science at the University of Western Ontario. Fred received the Phzor Prize of the History of Science Society in 1975; he and Harriet have three girls, Catherine, 19; Susan, 13; and Rebecca, 10.

Nsar Hossein is in Tehran, Iran, where he is Dean of the Faculty of Letters and Vice Chancellor of Tehran University, Chancellor of Aryamehr University, and Director of Iran's Academy of Philosophy; meanwhile, he continues to teach history and science. Whew!

Look for us next month. — **Dave Howes**, Secretary, Box 66, Carlisle, Mass. 01741; Assistant secretaries: **Chuck Masison**, 76 Spellman Rd., Westwood, Mass. 02090; **Lou Mahoney**, 6 Danby Rd., Stoneham, Mass. 02180

55

A tragic accident ended the life of one of our classmates on September 11. **Henry B. duPont III** died from head injuries suffered in an airplane accident. He was assisting a person out of his plane at the Block Island Airport when it jolted forward and spun around, throwing him off the craft. Henry duPont was manager of new business development at the Remington Arms Co. of Bridgeport, Conn. He was a resident of Fairfield, Conn., and had served as president of the Bridgeport Symphony Orchestra and as director of the Museum of Art, Science, and Industry, the Bridgeport Hospital, Atlantic Aviation Corp. of Wilmington, Del., and the University of Bridgeport. He is survived by his wife, Joan, and a son.

Lieutenant Colonel **Ernest D. Strait** has received the Meritorious Service Medal at Hickam Air Force Base, Hawaii. He was cited for outstanding duty performance as director of operations and maintenance at the Headquarters of the Pacific Air Forces. Colonel Strait received his M.S. degree in 1963 at Stanford University. . . .

William Chandler has moved to the Arkansas Delta Country to build a new $150 million paper mill. He writes that his kids have picked up the drawl already. . . . **Eric Theis** is Vice President of Marketing at the MRM division of Ecodyne in Massillon, Ohio. The firm manufactures large heat exchangers for refineries processing plants, and utilities all over the world. Eric finds the work exciting and he does a lot of traveling. As his four sons approach college age he has sounded a familiar cry. No sympathy here, Eric, I've already got one at college, and I had to mortgage the boat and the dog. . . . **Norry Hershey** has returned to Dallas, Tex., as Director of the Data Systems Division of the Army and Air Force Exchange Service. He is responsible for a large scale computer center with a telecommunications network extending from Munich to Honolulu. . . . **Frederic Hennie** has been appointed executive officer of the Department of Electrical Engineering and Computer Science at M.I.T. He handles a number of tasks including teaching assignments and appointments for the largest department of the Institute. . . . **Frank E. Perkins** has been appointed head of the Department of Civil Engineering at M.I.T. Previously he was special assistant to the dean of engineering for special education programs. His research interests center around hydraulic transients, hydrology simulation, and water resources planning and management.

Last, a couple of items about the class officers: **Ed Ehrlich** was chairman of the Technology Day '76 Committee. He is still Administrative Officer of Tufts New England Medical Center, and lives in natick with his wife, Janet, and their six children. . . . **F. Eugene Davis IV** was a Republican candidate for the Connecticut Legislature from the 144th House Assembly District in Stanford. It's too early at this writing to report the election results. One of your class secretaries, **Allan Schell**, is this year's Chairman of the Boston Section of the I.E.E.E., and he just won a close election to vice presidency of the I.E.E.E. Antennas and Propagation Society. (He was the only candidate). — Co-Secretaries: **Marc S. Gross**, 3 Franklin Ct., Ardsley, N.Y. 10502; **Allan C. Schell**, 19 Wedgemere Ave., Winchester, Mass. 01890

56

The Alumni Officers Conference in September gave a group of classmates the setting for a long visit. **Margie Gilson**, our retiring co-secretary, has a new position as a chemist with J.B.F. Scientific Company in Waltham. **Fred Worsh** is an active member of the Educational Council in upstate New York; he is also Senior Development Engineer at the Corning Glass Works plant in Clayton, N.Y., which he calls surburban Montreal. Fred's wife Betty has recently returned to college full-time. **Paul Polishuk** missed our reunion, which was the same day he moved from Washington to become president of Horizon House International in Dedham, Mass. He'll be involved in consulting, softward development and international applications — still in telecommunications. **John Stelling**,

a vice president of the consulting firm Thompson & Lichtner Co., enjoyed the A.O.C. and pointed out some of his work at the new Cambridge Hyatt House, which by the way, served us their very first banquet.

We enjoyed reviewing the diversity of occupations represented by our classmates at the reunion. **Rit Walling**, proprietor of East Coast Salvage Co. in Camden, N.J., thrilled some of the indoor-types with his underwater adventure tales; all-in-a-day's-work for Rit. . . . **George (Skip) Luhrmann** is a psychologist in Englewood Cliffs, N.J., applying analytic skills different from what we learned in the M.I.T. labs. . . . **Nick Wise** is proprietor of the Technology Products Group, an electronic manufacturer representative in Brookline, Mass. Nick is also becoming very active in local politics. . . . **Phil Trussell**, with Cabot Cabot & Forbes, has been project manager of the new Draper Lab building near M.I.T. . . . **Guy Spencer**, our co-secretary for 1966-1971, is really packing 'em in (at $1 each, notice!) as proprietor of the Community Playhouse movie theater in Wellesley; Guy has also been very active in local service clubs.

Lois and **John Pierce** are very active in a Cincinnati, Ohio, religious and personal counselling group called College and Career. John received his Ph.D. from the Sloan School in 1963 and was on the faculty there until 1967. Now, he is vice President of Management Decisions Development Corporation, which specializes in linear programming applications in the paper and transportation industries. . . . **Irwin Gross** is regional manager out of New York for the Sweet's Division of the McGraw-Hill catalog service for manufacturers. He, Ann and their children live in Westfield, N.J. . . . **Garry Quinn** moved this summer from Seattle to Washington D.C. where he will continue to work with Boeing Engineering & Construction Co. The move not only came during the worst D.C. weather, but also when Garry's wife, Raradi, was expecting their fifth child.

We're running low on reunion stories, so please send along some holiday greetings, and gossip to your co-secretaries. — **Bruce B. Bredehoft**, 3 Knollwood Dr., Dover, Mass. 02030; and **Warren G. Briggs**, 33 Bancroft Rd., Wellesley Hills, Mass.

57

A few items of news this month. First, **Bill Brandon** has been promoted to Associate Department Head in Satellite Communications Systems at MITRE Corp. Bill joined MITRE in 1966 from the Raytheon Co. where he was a project director on the Apollo/LEM program. During the past ten years, he has been involved in all aspects of MITRE's satellite communications work. In addition to his general responsibilities as Associate Department Head, Bill will be acting Group Leader of the Satellite System Design Group and continue as Project Leader of the Air Force Satellite Communications (AFSATCOM) II/III project. . . . Betty and I were very pleased to read in the *New York Times* back in June of the wedding of **Jordan Gruzen** to Lee Ferguson. Betty and I have gotten to know Jordan and Lee since we've been living in New York. Lee is on the staff of N.B.C.'s *Today* program. Jordan, as I've reported before, heads the large architectural firm here in New York bearing his name. . . . Eastman Kodak Company has announced the appointment of **Bob Sterret** as an assistant director in the paper service division at Kodak Park. Since Bob joined the company in 1957 he was have many different positions at Kodak's paper manufacturing organization including paper sensitising and color development. He received an M.S. degree in optics from the University of Rochester. . . . **Dexter Olsson** has been promoted to assistant to chief metallurgical engineer in the metallurgical division of Bethlehem Steel Corporation's steel operations department. His initial assignment in 1957 was with the corporation's shipbuilding department at Bethle-hem's former Quincy (Mass.) Shipyard. At Quincy, he advanced through a series of engineering positions and in 1964 he was transferred to the home office fabricated steel construction division. Within the corporation, Dexter has completed courses in nuclear physics and naval architecture and has been chairman of Bethlehem's non-destructive testing committee since 1969. He is a member of the American Iron and Steel Institute, American Society for Testing and Materials and the American Society of Non-destructive Testing. Dexter and his wife have two children. He is vice president of his local Lions Club and is chairman of the troop committee for the local Boy Scout troop.

You'll be hearing more in the coming months about the class reunion in June. I suggest that you get in touch with all your friends and plan to get together in Cambridge. — **Fred Morefield**, Secretary, 285 Riverside Dr., New York, N. Y.

58

Paul Rothschild has moved up to the position of Technical Director of the Plastic Products Division of Owens-Illinois in Toledo. . . . **Ken Smith** has been named acting head of the Chemical Engineering Department at M.I.T., succeeding Professor Raymond Baddour. Ken also serves as Associate Director of the M.I.T. Arteriosclerosis Center and has consulted extensively with industry on chemical products and processes. He and his wife, Ambia, and their four children are living, in Manchester, Mass. . . . **Chris Hahn** has been named Manager of Operations and Distribution for Shell Chemical Company's Agricultural Division in San Ramon, Calif.

Art Alexander writes: "After eight years as a research economist with the Rand Corp., I'll be going to London for a year's stay at the International Institute for Strategic Studies. Since my wife and I spent two years in London in 1963-65 when I was a graduate student at the London School of Economics, we are now looking forward to resuming the good London life (but with two children, things may be different.)" . . . I had occasion to talk by phone with **Skip Fitts**, who is now manager of the bookstore at Sweetbriar College in Virginia. Skip was previously managing the book department at the Harvard Coop. According to Skip the switch from city to country living has been very enjoyable for him, his wife, and their children. . . . I spoke recently with **Bob Jordon**, who is still leading the hectic life of a Washington attorney.

Conrad Rebak writes that there is "more technology in medicine, radiology in particular, than I ever dreamed possible — computerized tomography is brain-boggling. On a personal note, my wife and I now have two adopted girls, ages 4 and 2." . . . **Jim Braman** is now commander of the 410th Civil Engineering squadron at Sawyer A.F.B. in Michigan. Jim's comment is "It's pretty — but remote!" . . . As a member of the technical staff at Kuras Alterman, **Ed Vinarub** has been involved in a project for N.I.O.S.H. to develop instruments for measuring ultraviolet radiation in terms of its carcinogenic effects on the human body. Lately, Ed and Veronica report spending considerable time teaching their children, Vanessa, 7 and Jordan 3, the joys of ice skating and skiing. . . . **Daniel Brand** is now on leave from teaching at Harvard University while serving as Undersecretary of the Massachusetts Executive Office of Transportation and Construction.

It is time to wish you the very best for the holiday season and the New Year. — **Michael E. Brose**, Secretary, 30 Dartmouth St., Boston, Mass. 02116

59

Everyone must be saving their notes and letters for the Christmas rush. It has been a very thin mailbag. **William (Bud) Long**, writes from Marin County, north of San Francisco. He spreads his time among his wife and two children and an active schedule as the recently appointed Manager of Engine Lubricants at Chevron Research and local political activities with the Planning Commission and Flood Control Board.

Calvin Campbell is still president and one of the principal owners of Goodman Equipment in

Bruce Bredehoft and Margie Gilson, co-secretaries of the Class of '56 for the past five years, enjoyed the view of their 20th Reunion last June.

Charles G. Arcand, Jr., '61

Innovation vs. Management Science?

A fundamental conflict between innovation and management?

Charles G. Arcand, Jr., '61, whose job is to develop innovative fringe benefit programs for the Mutual Benefit Life Insurance Co., thinks big companies have trouble with innovation — Ford's Edsel and du Pont's Corfam, for example — simply because they're too big and too expert: they ask too many questions, too many people are involved in answering those questions, work situations are too tightly defined, and personal relations are impersonal.

The problem is that management science has brought many bureaucratic features — the kind we usually associate with conservative, old-line, production-oriented businesses — to modern organizations, writes Mr. Arcand in *Chemtech* (December, 1975) . . . "a renewed emphasis on rational, centralized, impersonal control, as opposed to intuitive management."

Top management is isolated from the points at which innovation is likely to occur, and "the very concepts of rational, scientific, and controlled management can make pursuit of innovation quite hazardous to middle management's career aspirations." So the modern organization turns out to be "not risk-seeking but risk-averting," and it has trouble with innovation "as a direct result of its learning to manage the established portions of its business." — *J.M.*

Chicago. Calvin, who graduated from Michigan Law School after M.I.T. and Williams noted that Goodman is one of the largest privately owned mining machinery manufacturers.

Our far eastern correspondent, **Adul Pinsuvana**, writes from Bangkok that he has left his position with Air Siam and offers his assistance to those who wish to build up a business empire in Thailand. Adul's wife has recently published a cookbook in English and Thai titled *Cooking Thai Food in American Kitchens*. Among the recent visitors to Bangkok were **Joe Towle** on travel from his base of activity in India and **Bruce Blomstrom** who is the Area director for Pacific and Far East Business Development for Abbott Laboratories out of Chicago.

A healthy and happy new year to all from the Secretariat of the Class, **Phil Richardson**, 180 Riverside Dr., New York, N.Y. 10024; **John Amrein**, 770 Greenwood Ave., Glencoe, Ill. 60022; **Adul Pinsuvana**, 49 Seri Rd., Seri Village, Hua Mark, Bangkok, Thailand; **Bob Muh**, 907 Chantilly Rd., Los Angeles, Calif.; and myself, **Allan Bufferd**, 8 Whitney Rd., Newtonville, Mass.

60

Richard Solomon has been named head of the social science department at the Rand Corp. Since 1971 Dick has been a senior staff member for Asian affairs on the National Security Council in the Executive Office of the President, and a visiting professor at the Johns Hopkins School of Advanced International Studies. Dr. Solomon has written two books on the Maoist transformation of China, and was a member of the political science faculty of the University of Michigan for ten years. Dick lives in Pacific Palisades with his wife, Carol, and their children, Lisa (10) and Jonathan (8).

The company over which **Dick Davidson** presides, Radmar, Inc., recently celebrated its fifth birthday with an order from the M.I.T. Library for audio-visual media storage containers. Dick says he hasn't heard from any of the M.I.T. crew. So if you pass through Chicago, call Dick in nearby Northbrook.

Ray Ambrogi is now manager of industrial product development in the Technical Staffs Division at Corning Glass Works. Ray has been with Corning since 1961, and he has been production superintendent at Corning's Big Flats facility since 1973. . . . **Don de Reynier** was promoted to manager of computer systems and technology support in the Management Systems Division of Procter & Gamble. . . . **Jason Speyer** has moved from Lexington, Mass., to Austin, Tex., to become tenured associate professor of aerospace engineering and engineering mechanics at the University of Texas. . . . **Roger Mark** has been appointed Matsushita Professor of Electrical Engieering in Medicine at M.I.T. Roger holds Ph.D. and M.D. degrees from M.I.T. and Harvard, and he directs the Biomedical Engineering Center, which is developing clinical instrumentation. He also is assistant professor of medicine at Harvard. . . . **Sheila Widnall**, M.I.T. professor of aeronautics and astronautics, received the honrary doctor of science degree from New England College, Henniker, N.H. . . . **Thomas Courtney**, professor of metallurgical engineering at Michian Technological University, is co-author of the college text, *An Introduction to Materials Science and Engineering*. — **Robert F. Stengel**, Secretary, 152 Oxbow Rd., Wayland, Mass. 01778

61

For the last couple of months I have been workng mightily on several research grant applications to all sorts of agencies, governmental and nonovernmental, so that I can expand my activities at Harvard Medical School. My fingers and brain are getting a bit groggy. Now the nail biting begins! Will they realize that the cure for cancer resides exclusively in their giving me all the money I am asking for? How about half? A third? You should see my letter to Santa Claus. I hope that you will get what you ask for too.

There have been several additions to class fam ilies. **Andy Buffington** and wife Sally "proudly announce" the birth of Katherine Buffington last July 26. . . . **Wesley Hilton** writes that he has adopted a Korean born boy, Bryce, and has aplied again, this time for a girl. Wesley says that **John Olsen** also has a Korean born child; his a girl of about 3. The Hiltons live in Del Mar, Calif., where he works for Scripps Oceanographic Institution. He reports that his sailing days are over and that he is lab-locked. . . . **Mike Wiederhold** reports the birth of his first boy: Theodore Lincoln Wiederhold last March. He was named after his two grandfathers, not in the spirit of the Bicentenial nor republicanism. Michael has been busy outide the house, too, with three research papers in the mill and a brave attempt at keeping three research programs going.

On the academic front, we all congratulate **Harold Meyer** on achieving nirvana — tenure — in the Department of Mathematics at Texas Tech in Lubbock. The professor lives, logically enough, in Lubbock with wife Judy and two boys, 4 and 3 . . . . Another of the chosen, **John Ritter**, has been promoted to a full professorship at the University of Massachusetts at Amherst. Last summer he went to England to enlighten them about fracture mechanics. The Ritter family enjoys skiing, camping, and gardening. . . . Further west, **Robert Abrams** is Associate Professor at the University of Chicago Graduate School of Business.

Charles Arcand wrote me a long letter describing his unusual academic activities. He is on the faculty at the University of Southern California. The odd part is that his classroom is in Plattsburg, N.Y., where U.S.C. has a graduate extension program at the Air Force Base! It seems to me that one of the attractions of U.S.C. is the warm California weather. So to go off to one of the coldest places in the country seems an extreme case of schizophrenia. He seems happy all the same. The two courses Charlie is teaching are Problems of Systems Technology and Systems Integration. He writes: "Since I obtained my M.B.S. at S.U.N.Y.A. in 1973, I have been involved in vari ous business, teaching, and futurist activities. By the way I married the former Bernadette Tubman, of County Leitrim, Ireland, in 1968 and we have two children, Alan, 6, and Lee Ann, 4."

Another letter comes from **Glen Stoops** who has also moved East from California. He writes: "The Stoops family spent eight years on the Monterey Peninsula. We even have two native Californians living with us now. Glen, 8, and Carole, 6, will both be in school this fall, and Anne is more than ready to have days of her own once more. I joined National Cash Register, Dayton, Ohio, in August, 1976, as a systems engineer, thinking about more and better electronic banking in the years to come."

Richard Miller is now near Chicago where "I'm Manager of Traffic and Distribution for AMOCO Chemicals Corp. We are living in Homewood. Julie enters junior high this fall, Sara is in fifth grade, and Eric just turned 3. Nancy will be looking for a new schedule of activities." . . . **Gil Stegen** writes that he has the last Morgan +4 coupe to have come to North America. That gives him room in the back to stuff daughter Tara, 3, and son Sloane, 6. Gil drives this remarkable machine to Flow Research, Inc. in Kent, Washington, where he is Manager of the Division of Ocean Sciences.

Still on the West Coast is **Peter Gaposhkin**, who works for the Navy as mathematician-programmer for the Fleet Numerical Weather Central in Monterey. . . . **Michael Davis** writes that he assumed command of the David Taylor Naval Ship Research and Development Center in Bethesda, Md., in August, 1975. . . . Also in the Navy, **Millard Firebaugh** was just promoted to Commander.

Henri Schnurmann writes, "I am about to complete my 12th year at I.B.M. where I am Advisory Engineer. Still involved in all aspects of testing large scale integrated circuits. I have just returned to East Fishkill, N.Y., after completing an intensive course of studies at the I.B.M. Science Research Institute in New York City." — **Andrew Braun**, Secretary, 464 Heath St., Chestnut Hill, Mass.

63

My cup runneth over this month. Not only do I have the usual supply of envelope flaps and press releases (including some left over from last month), but I also received two letters. I also have a bit of news of my own, which I will inject at the beginning of this column.

Barbara and I just returned from a two-week trip to England and Germany, where I presented a paper at the first International Tinplate Conference. The conference brought together people from 33 countries and who spanned all phases of the tinplating industry. My own paper dealt with research and development work that lead to an on-line gauge for the measurement of coating thickness of tin on steel. This instrument uses an X-ray fluorescence technique to measure coating thicknesses, and it is now the most widely used instrument of its type.

I did manage to combine a little sightseeing with the business part of the trip. Barbara and I visited the usual tourist attractions in London, and got a tour of some castles on the Rhine from an old Stanford colleague, now back home in Germany. We also paid a visit to Julia and **Larry Beckreck** at their home in the English Midlands. As I reported here before, Larry is working for an English firm, Genesys, which deals in software for civil engineering applications. The Beckrecks live in a 300-year-old cottage in the village of Longwhatten, south of Nottingham. I must report, however, that Larry is not preserving the house in its original state. When we visited, the installation of a central heating system was almost complete.

Well, so much for my own news. . . . Let me get on with some of yours. First, the letters you wrote. One was a joint effort from **Al Ramo** and **Warren Sewall**. On a trip to the Northeast last summer, Al and his wife Doris and son Richard stopped to visit Phyllis and Warren in suburban Philadelphia. Al is a geothermal geophysicist for Sunoco Energy Development Co. in Dallas, Texas. His hobbies have taken a conservative bent towards tennis and golf. (What — no more bridge?) Warren practices medicine (radiation therapy) in the Philadelphia area and still drives sports cars for fun and profit. . . . Class Treasurer **Steve Swerling** wrote of his continental traverse from Arthur D. Little in Cambridge, Mass., to work for Tektronix in Beaverton, Ore. At Tektronix Steve is a project manager in the Service Instrument Division. He was active in the M.I.T. Club of Boston during the last few years and served as president in 1975-76. Steve says it was a truly enjoyable experience and that more alumni should try it. He also chaired a session at Electro 76 in Boston last May. The symposium dealt with microprocessor testing.

Steve reports that all the cliches about Oregon are true — that it is a tremendous place, with tremendous pressures on it. He mentions that our class treasury is in good shape and that we have a nice nest egg for future activities. He suggests that our 15th Reunion might be in Portland, Ore. Hmmm, with so many of us on the West Coast these days, I'd say that suggestion deserves careful attention.

Some of you who included notes on your Alumni Fund contributions last spring must be wondering if those notes got lost in some filing system between Cambridge and California. Let me assure you that the Alumni Fund, your *Tech Review* editors, and yours truly are much more efficient than that. No, the notes are all intact, residing in an envelope on my desk. I'm feeding them out as rapidly as time and space permit. This month's offering will be current up to about last Memorial Day.

To begin with, Georgie and **Jim Hallock** write that they are the proud parents of a son, Alexander James ("AJ") born last November. Jim received the bronze medal for Superior Achievement from the Department of Transportation last May. This is the second highest award given by D.O.T. . . . **Raphael Solfer** is still with Bankers Trust, but now has responsibility for long range corporate planning. His sons Donny, 8, and Brian, 2, and wife Arlene are all doing fine. . . . At the close of 1975, **Rotislaw Prymak** left the Gillette Company, where he had been Systems Development Manager, to found his own company, Prymak Associates, Inc. (Another '63 enterpreneur!) The objective of the firm is to help U.S. consumer goods marketers develop singularly effective marketing strategies. Sounds interesting — let us know how your venture is working out.

Robert Dinsmore is project manager for Skidmore, Owings & Merrill, Architects, concentrating on "value engineered" health facilities construction. He is married, and has a 6-year-old son and a 2-year-old daughter. . . . **Howard Pielet** and his family are living in Lansing, Ill. He and his wife Barbara celebrated thier tenth anniversary last June. Sons Yakov, 7, and Eli, 6, attend the Hebrew Academy of Northwest Indiana. . . . **Mike Maul** is still at Bell Labs, Murray Hill, N.J., working on custom large-scale integrated circuits. . . . **Fred Deise** is practicing psychiatry in Palo Alto, Calif., and teaching as a clinical faculty member at Stanford Medical School. Fred is also doing research at the Palo Alto Veterans' Administration Hospital.

David Kleinman is now head of the systems group in the Department of Electrical Engineering and Computer Science at the University of Connecticut. He has received a $200,000 grant to do research in man-machine systems. . . . **Nelson B. Heller** is now executive director of the Institute for Public Program Analysis, a private non-profit research organization he and four others founded in 1974. Projects to date have dealt with police and fire services, and the evaluation of crime prevention programs. He reports that his daughter, Meredith, was born February 2, 1976. . . . **Albert T. Schwartz** writes that he relinquished his position as Dean of the Faculty at Macalester College this September, and returned full-time to the Department of Chemistry as an associate professor.

My typewriter seems to be running out of gas, so I think I'll end here. Please do continue to write — it's a pleasure to have material to put in this space. Happy New Year to all. — **Mike Bertin**, Secretary, 18022 Gillman St., Irvine, Calif. 92715

64

'64 has turned the corner; two months in a row of class heroes and notes. Keep up the good work.

A nice note from Ellen and **Gary Walpert** reports Gary is now practicing patent law with the firm of Kenway and Jenney in Boston and has bought a home in Weston. Ellen recently had her second law outline book published, and their daughter Tara Ellen is anxiously awaiting the October arrival of a brother or sister. Being delinquent in class note submissions as we usually are, we can now congratulate Gary and Ellen on the birth of a second daughter; both mother and daughter are fine.

Len Parsons has "finally succumbed to my heart-rending appeals for news." It's been a very good year for Len. He is co-author of two books, *Marketing Management* published by John Wiley and *Marketing Models and Econometric Research* published by North Holland, and has written a couple of articles for the *Journal Of Marketing Research*. After being named Associate Editor for the journal *Decision Science* and selected to be on the Program Committee for the American Marketing Association's International Conference, Len received a Fulbright-Hays Award to be a Senior Scholar at the Katholieke Universiteit Louven (Belgium) for the first seven months of 1977. Len is presently Associate Professor of Marketing at Claremont Graduate School; we'll catch you up with the family half of Len's letter next issue.

Now to our news from Alumni Fund envelopes: **Robert Clark** has been with the Criminal Securities Fraud Unit of the Department of Justice for six years. Currently he is the lead attorney investigating the foreign payoff cases. He and his wife have a 9-month old son. . . . Commander **Douglas Currier**, formerly Chief of the Ninth Coast Guard District Electronic Engineering Branch in Cleveland, Ohio, has been transferred to St. Petersburg, Fla., where he is Commanding Officer of the CGC. *Steadfast*, a medium-endurance cutter which patrols the Florida coast. . . . **George Harlem** is marketing manager for Codex Corp., in charge of the Asian, Pacific and Americas markets. He, his wife Rosina, and their two daughters are living in Acton, Mass. . . . **David Hoover** has joined the academic world as Director of the University Budget at New York University, where his wife Carol is an Assistant Professor.

Linda and **Lawrence Kaldeck** report the birth of their first child, a son named Steven Alan, born on April 8. . . . **James Monk** writes that all his spare time will probably be spent in fixing up the 100-year old house he recently purchased in Concord, Mass. . . . **Herbert Norton** has moved back to the Midwest. He, his wife and two daughters now live in Glen Ellyn, Ill., where he is doing computer science work at Bell Labs in support of Electronic Switching systems. . . . **Albert Teich** is now Associate Professor of Public Affairs in the Graduate Program in Science, Technology, and Public Policy at George Washington University in Washington, D.C.

For our part, George has settled comfortably into the local second grade and Lewis is delighted with nursery school. I have managed two entire months without travel, a rare occurence which is to end abruptly in November (long before this goes to print) with trips to San Francisco, San Diego, and Arlington (Texas), the last of which is this year's host for the I.E.E.E. Autotescon, where I am giving a paper. Our "new" home is working out well and we await your calls and/or visits when you're in the area and your letters and notes wherever you are. Shalom! — **Steve Schlosser**, Secretary, 11129 Deborah Dr., Potomac, Md., 20854.

65

It has been a gorgeous autumn day in New England. With the long lead times necessary, there may well be snow on the ground by the time you read this, so this is to remind me that the weather here can be pleasant at times.

At the other end of the weather spectrum is **Bill Brody**. After getting his master's from M.I.T., Bill got his M.D. from Stanford, was an intern and resident in surgery at the N.I.H. Heart Institute, and now is doing a residency in radiology at the University of California, living in Mill Valley. . . . Another Californian, **John Holdren**, spoke recently at a colloquium in Virginia, on "The Nuclear Power Controversy." . . . **David Cannell** has been promoted to Associate Professor of Physics at the University of California at Santa Barbara.

Barry Wessler wrote to say that he has been with Telenet for three years, having watched it grow from five to over 70 people. The Wesslers have two children, Michael (6) and Emily (3). . . . **David Rubin** is finishing his second master's degree, in administration at Johns Hopkins, and is working for the Maryland Department of Transportation. Sharon is heading a college program in individualized education.

Richard Amster gets the "most exotic" award by a wide margin. We learn from his family that Dick and two others sailed from the Maldive Republic to Sri Lanka (Ceylon) in a 30-foot "dowhny," a fishing boat of coconut wood held together with rope.

As previewed by your intrepid reporter in the July/August *Review*, **Bruce Morrison** was ap pointed Executive Director of the New Haven Legal Assistance Association. Jane Morrison is Dean of Admissions of Wesleyan University.

With the weather getting colder, Bruno has naturally decided to begin shedding his coat in typically perverse St. Bernard fashion. Please write, so next time I shall be so busy with this column that I do not have time to work on the clean-up. — **Edward P. Hoffer**, Secretary, 12 Upland Rd., Wellesley, Mass. 02181

66

As promised last month, I will try to bring you up to date regarding some of the reunion attendees.

M.I.T. Multics vs. MITRE Engineers

Now it can be told: for six to eight months early in the 1970s MITRE Corp. was able repeatedly to gain free access, unauthorized, to all files in M.I.T.'s big Multics computer; the eavesdroppers' presence was never detected. To finally prove that it had conquered what M.I.T. thought was an impregnable computer security system, the MITRE team obtained from the computer the only existing copy of its deciphered master password list; because of the enciphering scheme used, not even M.I.T. had one.

Nothing criminal was involved; it was all in the interest of science — part of an effort by MITRE Corp. to understand and solve computer security problems for the Department of Defense, says Steven B. Lipner, '65, who discussed the work at a staff seminar for his MITRE Corp. colleagues early this winter.

Most large computers are used for many different tasks — from computing payrolls to analyzing military strategy — and "there has to be some kind of protection to keep those applications separate." Some computeried data is classified, some not, and some users even find themselves relying on the computer for the primary security of classified information. It's a difficult — and important — problem.

Most computer "leaks" occur through "software" weaknesses. That's because back in the 1960s, when most of today's big "software" programs were being designed, "security wasn't a design problem; the focus was on getting the computer to work," Mr. Lipner said. Now it's a question of modifying "software" to meet security needs.

Occasionally Mr. Lipner and his colleagues find a flaw in the computer hardware that leads to a security "leak." That's a wholly different class of problem, he said. "Wired-in flaws are very hard to solve, and they aren't getting the attention they deserve, mainly because 'software' vulnerabilities are so rampant."

"We Just Couldn't Do It"

MITRE's work in computer security began when the Air Force Data Service Center asked MITRE Corp. for an on-line data management facility for a new installation of computers. "And, by the way, make them secure," said the Air Force.

"Naive as we were," said Mr. Lipner, "we said, 'Sure.' Then we found out we just couldn't do it." But after five years of effort, Mr. Lipner told the MITRE seminar, "we believe we have made considerable progress. . . . What we are doing that is significant and different," he said, "is trying to provide enforcement of the Department of Defense security policy. We believe that's important for a system that is going to protect defense information."

The Longest Travel Award went to **Carl Jones** who came in from Menlo Park, Calif., accompanied by his wife, Lenore Haas, '69. It was a close competition, as **Dan Allen** came in from Los Angeles with his family and **Jerry Abraham** flew all the way from La Jolla, Calif. Carl is with Tymshare, Inc. **Bruce Powell** and his wife, Sue Ellen, came in from Philadelphia where he runs Tymshare's office. Bruce and Carl were not aware they are working for the same firm until the reunion. **Wayne Baxter** came up from Marietta, Ga., with his wife, and was elected Class Chaplain. **Larry Schwoeri** was elected Class Agent and is living in Boston where he works for Medi, Inc.

Other from the Boston area included **George Berbeco**, **Howard Cohen**, **Franz Birkner**, and **Bill Byrn**. Franz had been with the Boston Consulting Group and has recently gone out consulting on his own. Bill is with Index Systems, Inc. Index has been doing a lot of consulting for Citibank, so I have had many occasions in the last couple of years to see him in New York.

Mike Kinkead, his wife Marilyn and daughter Courtney, are living in Boston where Mike is president of his own systems company, specializing in developing accounting and management information systems for banks. . . . **Allen Post** lives in Framingham and was confronted at the reunion with some ten-year-old pictures of himself from undergraduate days (crew cut, narrow ties, and all). . . . **Bert Barrington** and his wife Pat came in from Owattona, Minn., where Bert is an opthamologist. . . . **Marland Whiteman** came up from New York where he is with IBM. Marland and I had lunch a couple of months ago. He has stayed close to "wrestling" condition and is doing a fair amount of hiking.

One of the highlights of Saturday night was seening M.I.T.'s Historical Collections. On file are all the old architectural theses and we were able to locate **Joe Blew**'s and evaluate it. Finally, **Bill (Moose) Kosinar** was at the reunion with his wife Pat. Bill is a Senior Investment Officer with New England Life. He reports the recent purchase of a 1971 convertible with 260 horses and can be found drag racing around Boston.

Correspondence received over the last month includes the following: **Al Inversin** writes that he returned to the States last year after six years in Laos. He's completed educational courses at the University of Maryland and is about to set off to Papau, New Guinea. . . . **David Liroff** writes from Ohio where he is Program Director of Ohio University's PBS Stations. David got out of teaching last year but "still bears the cumbersome title of Adjunct Assistant Professor of Radio-Television.". . . . **Bill Friedman** is Associate Professor of Physics at the University of Wisconsin. . . . The *U.S. Investor/Eastern Banker* magazine indicated that **Karl Moller** was recently elected assistant secretary and actuary at Home Insurance Company. . . . **Bob Marsh** and his wife Carole are pioneering a new town in Arizona, Fountain Hills, just outside Phoenix. Bob is a project manager at Honeywell's Process Control Division in Phoenix, and spends weekends exploring the West. . . . **Jeff Kenton** moved to Wellesley two years ago, where he's working as an independent consultant specializing in small computer software.

I had to work a little to get news for this issue. Given the lack of articles over the past two years there has to be a lot of pent up information out there. Please try to keep it flowing. Happy Holidays to all. — **Paul Rudovsky**, Secretary, 340 East 64th St., Apt. 10B, New York, N.Y. 10021

67

Happy Holidays. The tenth anniversary for our class will be rolling around in June, and I hope that many of you will be able to attend the festivities at Tech. (I am not presently aware of specific plans for the reunion; we are certainly open to suggestions.)

Jack Farber started his residency in psychiatry last July after receiving his M.D. degree from University of California at Davis. . . . **Yupo Chan** is on the Penn State faculty teaching and researching in the areas of transportation systems analysis and land use planning. Until 1974 he was with Peat, Marwick, Mitchell and Co. in Washington, D.C. . . . **Richard Simpson** is Research Associate at the Center for Radar Astronomy at Stanford and has spent most of the past year involved with the observation of Mars for N.A.S.A.'s Viking project. . . . Susan and **Gerry Tomanek** have a son, Stuart, born January, 1976. Susan received her M.B.A. from Stanford the same year and was voted the Best Two-For-One Split in her class. Jerry is Sales Manager for Acurex. . . . **Jerome Milch** is Assistant Professor in Cornell's Program on Science, Technology and Society and in the School of Business and Public Administration. He and Anita have a daughter, Karen Lynne, born January, 1975. . . . Myrna and **Bob Karz** should have their second child by the time this appears in print.

Having tired of the Navy bureaucracy, **Tom Curtis** has returned to academia and is pursuing his doctorate in civil engineering at University of Minnesota. . . . After being promoted to Assistant Professor of Mathematics at University of Miami, **Fred Keene** resigned to accept a lectureship at California State College, San Bernardino. . . . **David Saunders** has two children and is Research Associate in the Department of Human Genetics, University of Michigan. . . . **Gary Powell** has a Ph.D. in business administration from University of Massachusetts. Last fall he became Assistant Professor in the University of Connecticut Business School where he is teaching and doing research in organizational behavior and theory. . . . **Felipe Pradas** has left the institutionalized consulting field and become an independent consultant, which is apparently less restricting and more profitable. Taking advantage of a consulting assignment in Mexico, he and his wife roamed the Yucatan Peninsula exploring the Mayan ruins. . . . **John Rudy** and his wife have their second child, Hilary Beth. — **Jim Swanson**, Secretary, 669 Glen Rd., Danville, Calif., 94526

68

Greetings again as the winter solstice approaches. It may seem like only yesterday that we graduated, but our tenth reunion is only 18 months away. Therefore, we'd like to form a small group to start making preliminary plans. If you are interested, please drop us a card.

We received a note from **Chris Davis** recently. He spent a year in Keflavik, Iceland, as an Air Force flight surgeon and upon his return stateside was named "Flight Surgeon of the Year — 1975." The award was for improvements he created in arctic emergency medical/survival equipment and for several lifesaving missions. He has now left the Air Force and is a resident in emergency medicine at Johns Hopkins Hospital. He hopes to have a career in teaching emergency medicine . . . . **John Niles** has co-authored a new book, *The New Management: Line Executive and Staff Professional in the Future Firm* (McGraw-Hill). The book describes how trained staff professionals such as computer specialists and behavioral scientists can be more useful to corporate managers than is usually the case in present business firms. The co-author is William Gruber of the Sloan School. John is still working in the Distict of Columbia mayor's office and is pleased that the city is making progress. . . . A note from **Carol Botteron** reports that she is still at Houghton Mifflin Company where she edits science textbooks. She adds, "I've taken up dancing — I do a mean tango."

Winston Gardner received an M.B.A. from Rider College in July. . . . Also in academia, **Robert Strider** has become a part-time lecturer in economics at Colby College. He is also a vice president of Maritime Trading Co. and a consultant to the Federal Energy Administration. . . . **Brooks Hilliard** has become Manager, Product Marketing, for Sanders Data Systems and has purchased a house in Sudbury. That's all for this month. See you in 1977.— **Gail** and **Mike Marcus**, Secretaries, 2207 Reddfield Dr., Fall Church, Va. 22043

70

Seasons Greetings. **Steven Cushing**, after receiving a M.S. degree at U.C.L.A., proceeded to receive his doctorate in linguistics. . . . **Louis Edelson** writes that he is commencing his internal medicine internship at Mt. Zion in San Francisco. . . . **John Huchra** also just completed his Ph.D. in astronomy at Cal Tech and has taken a research fellowship at the Smithsonian Astrophysical Observatory. . . . Finland is the place where **Seppo Halme** has distinguished himself by being chosen as a member of the Academy of Engineering Sciences. In addition, he was recently reelected as President of the Society of Electronics Engineers.

Nancy Houghton and **Robert Fleischer** were married this summer. Nancy will be a graduate student at Leslie, while her husband is working at MITRE in Bedford. . . . **James Stahler** is a systems analyst at Computer Sciences Corp. in Falls Church. . . . Where is **Ernie Gladney**? . . . Xylogic Systems of Burlington has employed **Alain Hanover** as Director of Copy Processing systems. Carol and he traveled to Geneva to give a paper at a newspaper technology symposium. The family lives in Framingham with children Judith and Daniel. . . . **Robert Schaller** secured his Ph.D. in physics from the University of Denver and stayed in Colorado as an assistant professor in physics at the U.S.A.F. Academy. . . . The same degree was received by **L.J. Azevedo**, who has followed it with a post-doctorate at U.C.L.A. He is racing his bicycle again. . . . **R. Nagy** has been with the U.S.A.F. in Colorado Springs for four years and dreads the change of station orders. He has heard from **Gary Fiske**, who is having a "hell of a time" in Berkeley.

Stephen Memishiam has moved to Beverly Hills after six years with McKinsey and Co. in New York as a management consultant. He is now vice president and special assistant to the president of Columbia Pictures. . . . **E. Worthington** is pursuing counseling psychology as a graduate student at the University of Missouri at Columbia. This is after four years as an instructor in the Naval Nuclear Power School. . . . **Frederick Kuo, Jr.** is a registered professional engineer in New York, senior engineer in the Mechanical-Nuclear Dept. of Ebasco Services. . . . Master's degrees were received by **Luther Tai** in chemical engineering (City College) and industrial engineering (Columbia). He married Johanna Cheng (Fu Jen University) and they have a new addition. . . . **Charles Lieberman** is an assistant professor at the University of Maryland and has purchased a home in Silver Spring.

In this year of uncertain crop yields, **Michael Kearns** has tripled his crop of oranges, in addition to passing his Ph.D. qualifiers. He wants to know what has caused the weighty silence form '70.

Jeffrey Ellison is vice president of John R. Ellison and Sons, Mechanical Contractors; he and Cheri have three boys, and have a new home address in Butler, Penn. . . . **Steven Hendryx** left the Boston Consulting Group to accept a position as manager of operations of a new firm in Menlo Park, U.S. Para Plate. It manufacures a newly-patented pressure control device. . . . **L.W. Miles** is president and C.E.O. of University Patents, Inc.; Trustee of Fairfield University; Director of Gruen Industries, and Director of A.A.T. Airlines. . . . I.B.M. has claimed another classmate. **Arthur Davidson**, after graduating with a Ph.D. in applied physics from Harvard, headed for Yorktown Heights, N.Y. . . . **Earl Withycombe** wanted us to list several of his 25 (!) occupations since graduation. These include: iron-worker, actor, gravedigger and clinic administrator.

Polaroid's Polymer Development Lab is where **Carolyn Lee** has spent the last three years. She also indicates that she and S. Gabeler love their house in Sudbury. . . . Eastman Kodak has recently promoted **Bruce Becker** as Manager of Financial Planning and Reporting of the International Photographic Division. **Bill Copeley** has been moved in a different employment direction by being assistant librarian at the New Hampshire Historical Society. He is studying hypnotic regression as a historical research tool and plays White Mountain fiddle music in his spare time. . . . **P.R. McCreary** has continued in his occupation of the past three years of teaching alternative studies in the Urbana high school system. He works with three other staff members and approximately 70 students, who sign up for this three-year option. . . . **E. McCann** has been recently promoted to a position which may help relieve the transportation problems of the "energy crisis." He is now Chief Planner in the Maintenance and Repair Dept. of the Chevron Shipping Co. He plans for worldwide repairs of Chevron's fleet of tankers. . . . **Bob Bowden**, in addition to enjoying northern California life with Martha, is employed as a Product Manager for Hewlett-Packard after a stint at H.B.S. . . . **G. Buma** is managing a joint research effort for Westinghouse, a French firm and German firm to develop solution mining of uranium. He will spend "$1.8 x 10^8" over the next three years.

Unfortunately, a note was received concerning the death of **Barry Lake**. As a student, he was closely associated with WTBS.

I noted with particular interest the appointment of **Gayn B. Winters**, Ph.D. '70, Assistant Professor of Mathematics at Holy Cross. Many of us had him for differential equations (18.034). We became reacquainted in my first year of law school at Indiana University, where he was teaching algebraic geometry. — **Robert Owen Vegeler**, Secretary, Kennerk, Dumas, Burke and Backs, 2120 Fort Wayne National Bldg., Fort Wayne, Ind. 46802

71

Ed Buchak married Bonnie Shaw on June 29, 1974 in Boyertown, Penn. . . . John Dieckmann, '73, was best man; **Frank Taylor** and Mike Stauffer, '72, also attended. Ed is now a partner in Edinger Assoc. of Wayne, Penn., a small consulting firm specializing in water-related environmental problems. Ed saw Bob Armstrong, '70, and his wife, Nancy, in Southern California, Rita and Jim Roxsio, '72, and Jim Wood, '73. Ed can be contacted at 981 Oak Crest Lane, Media, Penn. 19063. . . . **Mitch Serota** wrote that he went to Paris for doctoral research as a French Government Scholar and ran into some phone hackers who devised a system where they could call anywhere in the noncommunist world for free (Mike Bromberg, '70, are you reading this??). He returned to Chicago and worked for a bank while finishing his doctoral thesis for the University of Chicago in history. The job market for a Ph.D. in history was terrible, so after some traveling he found a job with C.N.A. as an actuarial technician. Mitch wrote: "In conclusion, the Ph.D. was an ego trip, but it frightens the business world so much that they cannot understand the motivations of an individual who grinds to get it. Without my background (in math) at M.I.T. I would still be unemployed and perhaps unemployable. . . ." While traveling in San Francisco he saw **Marc Roddin** who is traveling around the world as a transportation consulting analyst for the Stanford Research Institute.

Tom Tate just finished his tour as a naval officer for the *U.S.S. Kitty Hawk* and his course work for an M.B.A. at Stanford. His wife Sally ('71, Boston University) is an excellent cook. . . . **Demetrios Matsakis** is an astrophysics student at University of California. . . . **Rob Pepper** was married to B.G. Ledgard in Manchester, Conn., September 12. Some M.I.T. classmates and friends made it to the wedding and had a great time. Rob and his wife are now on their way to Mexico to spend the winter.

Walter J. Daub has obtained a large interest in Flank, Snorters and Co., a clothier supplier with outlets in Dallas and Kansas City and has written his first book: *Okra is My Life*. . . . The Rev. **John H. Morgan** has been named pastor of the Shelton Congregational Church. He graduated from the Bangor Theological Seminary in '74, and is married to the former Barbara Sanford of Oxford. They have two small children.

Howard L. Siegel writes: "In August I will be completing my second year as a an associate with the law firm of Hoberman & Pollack in Hartford,

Deborah J. Jackson, '74 of Itta Bena, Miss., worked on x-ray studies of crystals last summer at Bell Laboratories in Murray Hill, N.J. Deborah was awarded a fellowship by Bell Labs for studies leading to a doctoral degree.

where I have been working since graduating from Boston University Law School. Last December Barbara and I bought a condominium in Rocky Hill, Conn., and this spring we have been touring the area on our latest acquisition, a bicycle built for two." . . . **Gary H. Lantner**, General Manager of the South Terminal Corp. at Logan Airport received his J.D. Degree from Suffolk University.

It is my sad duty to report that **Stewart Frost** died on July 27, 1976. — **Hal Moorman**, Secretary, P.O. Box 497, Brenham, Tex. 77833

72

Here I am again after a little unauthorized vacation. It's difficult to force oneself to the typewriter on those balmy summers days when you are supposed to be writing fall columns.

We are beginning to make plans for a fifth reunion. The chairman will be **Paul Levy**, and anyone who would like to help out ought to get in touch with him at 94 Parker St., Newton Center, Mass.

John Bissell writes, "I just returned from Teaneck, N.J., where I was an usher at the wedding of **Len Sigal** (who just graduated from Stanford Medical) and Judy Halden on June 6. After a honeymoon in St. Maarten, Len will start residency/internship at Mt. Sinai in New York. Best man **Steven Goldstein** and wife flew in from Cincinnati where he is a patent attorney for Proctor and Gamble. **Mark Stern**, now doing his residency at Long Island Jewish Hospital, was the other usher. Other Bakerites in attendence were **Bill Shields**, who just graduated from Columbia Law, and Barry Davis, '73, with his wife Wally. I have just returned to Cape Canaveral where I am working for IBM on the Launch Processing System for the Space Shuttle.". . . . **Ken Kempson** was married to a fellow Navy Officer in his '74 OCS class. . . . **Norman Kohn** got his M.D. from Yale and is interning in Cleveland. . . . **Martin Bilsker** graduated from Duke Medical School and is an intern at Montifiori Hospital in New York.

William Wike reports, "I have opened an 'Import Car Parts, Unlimited' in Bloomington, Ill. It is a business adventure that goes hand in hand with my auto repair shop. On May 10, 1975, Penny had a baby boy, William James Wike.". . . . **Kevin Trangle** finished his senior year at the University of Minnesota Medical School, and is spending this year in Swaziland doing clinical medicine and a research project on schistosomiosis. . . . **Randel Frazier** is working for 3M in Brookings, S. Dak., as an advanced production engineer. He writes, "South Dakota is sure different from San Jose, where I've lived for the last four years.". . . . **Joe Litten** reports, "I am working in San Francisco for the Municipal Investment Banking Department of Dean Witter and Co. We assist states and municipalities with their tax exempt financing. My wife Janice works for a competitor, so it makes life interesting at home. I see **Ted Trueblood** in my travels to Anchorage." . . . After finishing in February, 1974, **David Glen** spent two-and-a-half months traveling in Europe. He is now working as a scrap metal buyer for an aluminum recycling company.

Lee Brown graduated from Mt. Sinai School of Medicine and is an intern in Internal Medicine at Mt. Sinai Hospital. . . . **Donald Layton** lives in New York and works as a special assistant to the vice chairman of Manuracturers Hanover Trust. He is married to Sandy Lazo, '74, who works for an economics consulting firm. . . . **Steven Jacques** is working part-time in a hospital and part-time as a volunteer at a free clinic. He writes, "I am very poor right now, but living a full life.". . . . **Marc Alpert** got his medical degree from the University of Pennsylvaia and is now in Boston for five years of surgical training at the B.U. Medical Center. . . . **Richard Ku** got his doctorate in physics from Columbia and is a postdoc there this year.

Richard Anderson writes, "I have left Boston at last. The two-and-a-half years after graduation were spent investigating ultraviolet photobiology of human skin at Harvard. It was hard to leave behind that exciting and rewarding work to become the director of a small rural Quaker school called Tamarack Farm Community in Plymouth, Vt. Teaching, working, living and farming within this community-oriented school has intergrated my life a great deal.". . . . **William Gahl** got his M.D. from the University of Wisconsin and is now a resident in their pediatrics department. . . . **Steven Shantzis** is conducting work in energy economics and financing with Booz, Allen, and Hamilton, management consultants in Bethesda. — **Dick Fletcher**, Secretary, 135 West St., Braintree, Mass. 02184

74

First things first: **Harvey Michaels** is getting married December 26. I forgot who he is marrying or where the wedding is, but at least I remember the date! If you are interested, then call Harvey — he's in the Boston area.

Speaking of marriages, **Ed Kronenberger** was married last year to Susan Nygard, S.M. '75, and they are presently living in Alma, Mich. Ed writes, "I'm working for the Dow Chemical Co. in Midland and Susan is now working for Seismograph Services Corp. here in Alma."

Barry Buchbinder writes, "I passed my written prelims in molecular biology but still have my oral research proposal presentation to do. I'm doing research on the control of protein synthesis in green beans.". . . . **Jamie Silverstein** writes, "After a two-month vacation in Italy and Israel after graduation, I have been working as a consultant at Data Resources, Inc. in Lexington, Mass. I enjoy the job tremendously. I'm learning a lot about economics and business and am getting a chance to travel around the country. I would love to hear from M.I.T. friends."

Deborah Jackson has received a Bell Laboratories Fellowship for her doctoral studies at Stanford University. Deborah was working on x-ray studies of crystals in the Chemical Physics Research Laboratory at Bell Labs in Murray, N.J., during the summer. . . . **Norman Mazer** has been named an Insurance Medical Scientist and has received a special two-year scholarship from Connecticut Mutual Life Insurance Co. for his joint M.D.-Ph.D. program at M.I.T. and Harvard Medical School.

Hoping your news is good news — **Dennis Dickstein**, 17 Forest St., #34, Cambridge, Mass.

75

Lew Weinstein writes, "For the past year I have been with the investment banking firm of Goldman, Sachs & Co. in New York, doing economic and bond market research. I've kept in touch with several classmates, including **Allan Kornberg** (Mount Sinai Medical School), **Allan Schimmel** (Buffalo Medical School), and **Rich Barron** (working in Boston)." . . . **Thomas F. McKim** says: "I have just completed my first year at the University of Chicago Law School. I spent the summer following graduation obtaining an instrument rating to add to my commercial flying license. I've encountered an unexpectedly large percentage of engineers in law school, perhaps indicative of a growing trend." . . . **Edward Weinberger** is now in his second year at Harvard Medical School. He says it's a lot of work but well worth it. . . . From the *News-Tribune* of Waltham, Mass., I see that the technology division of G.C.A. Corp. has named **Walter T. Stanley** chemical engineer in the division's Environmental Engineering Department. He's evaluating sulfur dioxide emission controls in industry.

And now for some wedding announcements: **Neil A. Rosenberg** was married to Nancy Knightof Wellesley on July 27, 1975. Neil is now getting aMaster's at Stanford and intends to stay in Palo Alto. . . . P. R. Webber informs me that **Robert Schreiber** was married to Janet Carney (Boston College, '77) in Chatham, N.J., on August 14, 1976 Bob has recently taken a job with an engineering firm in Boston and will live in Newton. . . . And though I think I may have included this in another column, I'll report once more that **Alan Lefkof** and Ann Gordon (Wheaton College, '75) were married on June 20, 1976, in Cleveland, Ohio. They both have completed the first year of graduate school at Harvard. Alan is working on his M.B.A. at the Business School and Ann is studying city planning toward an M.C.P. from the School of Design.— **Jennifer Gordon**, 5 Centre St.,Apt. 32, Cambridge, Mass. 02139

76

N.B. For those '76ers for which this will be the first issue of *Technology Review* they'll have received, our class notes have appeared in the last two issues.

I hope **David Gabai** is completely recovered from his automobile accident. I didn't get many details, but I did hear that he will make a full recovery. Dave is a grad student in Mathematics at Princeton. . . . **Stan Arbesfield** is now doing independent research in linguistics and physchology. He told me he hopes to publish some of the papers he has written. At the time I spoke with him, he had written in excess of 600 pages. And he doesn't have writer's cramp. . . . **Gail Rubin** and **Jim Miller** may now both be found working for Bolt, Beranek, and Newman in Cambridge. Gail is a systems programmer and Jim is a computer scientist for them. I learned from Gail that **Bill Anderson** is a grad student at the 'Tute in mechanical engineering, and **David Anick** and **Steve Pincus** are grad students in mathematics, also at M.I.T.

Gretchen Megowen, who is at Tufts Medical, married Michael Jung, '75, (he's at Harvard Law) on June 19. I heard also that **Ralph Troiano** and **Jim Lambert** each got married, but my "informants" couldn't give me any more details. Also, I was tipped off that **Irja Luoma**, who is now a grad student in metallurgy, married Thomas Susa, '73, on August 21 at the M.I.T. chapel. Thomas is a chemical engineer for a local Massachusetts firm.

David Blanchard and **Melissa Weiksnar** (both September, '76 graduates) were married on August 28 at the M.I.T. chapel. They now reside in Houston, where David is doing space shuttle engineering research with McDonnell-Douglas and Melissa is working with Conoco's engineering group. In writing to me, they also tell me that Houston has bigger cockroaches than Cambridge. I had heard about Texas and their claims of "largeness" and now, I believe!

In addition, **Stephen Holmes** married Susan DiGiacomandrea on September 18 at St. Margaret Church in Dorchester. They're now living in Dorchester, but as to what they are doing, my source didn't tell me. Sometimes, being secretary can be frustrating.

To make up for the frustrations, I do have more news. **David Lee** is at McGill Medical. I hope he doesn't freeze to death this winter, as those cadavers don't make for warm company. In the cadaver department, **Bill Williams** is to be found at Tufts Medical, **Jeff Baerman** at University of Chicago Medical, and **Jim Streisand** is at C.U.N.Y. Buffalo Medical.

Leaving cadavers for livelier topics, we find **Nick Koreisha** is an engineering officer for the U.S. Navy stationed on board a ship in Pearl Harbor. With the advent of winter, I hope he'll read this and send me a postcard letting me know how the climate feels. Also in a warm climate is **Rusty Saunders**, at the Stanford Business School. . . . **Chris Tracy** is working for Dynamics Research here in Massachusetts as an engineer. To learn this, I blew my car battery on Mass. Ave. I hope you all appreciate your secretary pushing his car down Mass. Ave. to a gas station after collecting this and sundry other bits of news. . . . **Margaret Hainsworth** is a sales assistant for I.B.M. at their Boston office. She is now attending system design classes in Endicott, N.Y. I got the news and wound up helping her move to Allston.

That's all for this month. Why don't some of you write? It would save me batteries and sweat. — **Arthur J. Carp**, Secretary, 67 Badger Cir., Milton, Mass. 02186

J. J. Connor, Jr.

Sea Grant Research Director

Jerome J. Connor, Jr., '53, Professor of Civil Engineering who heads the Department's Constructed Facilities Division, is now Director of Research for the M.I.T. Sea Grant Program. His job, says Walter A. Rosenblith, Provost, will be to plan and coordinate research and the dissemination of its results; the goal, says Dean A. Horn, N.E. '49, Sea Grant Program Director, is to "strengthen and focus Sea Grant's research efforts."

Professor Connor's three degrees in civil engineering are from M.I.T., and he joined the faculty in 1962 upon completing his Sc.D. His recent research has been in numerical modeling of coastal processes, and he has been principal investigator on the Sea Grant's major study of circulation and dispersion patterns in bays and estuaries of the Massachusetts coast and adjacent waters.

Matsushita Professorship

To support work in technology for "urgently needed advances in health and medicine," the Matsushita Electric Industrial Co., Ltd. of Osaka, Japan, gave M.I.T. a $1 million Matsushita Professorship last winter (see *Technology Review* for March/April, p. 80). Now there are two occupants of the Matsushita Chair: Ernest G. Cravalho, Matsushita Professor of Mechanical Engineering in Medicine, and Dr. Roger G. Mark, '60, Matsushita Professor of Electrical Engineering in Medicine.

Professor Cravalho, who's been a member of the Department of Mechanical Engineering since 1966, has worked on the application of cryogenics to problems in biology and medicine — especially the preservation of blood cells; he's been Associate Dean for Educational Programs in the School of Engineering since 1975.

Dr. Mark studied medicine at Harvard Medical School, and he also holds a doctorate in electrical engineering from M.I.T. He's the Director of the Biomedical Engineering Center, applying techniques of microprocessors to the development of clinical instrumentation, and he's also Assistant Professor of Medicine at Harvard.

Engineers Learn Policymaking

If engineers are more and more affected by public policy, let them understand policymaking and be ready to make their share of it, reasons Richard L. de Neufville, '60, Professor of Civil Engineering, who is the founding Chairman of a new master's-level Technology and Policy Program in the School of Engineering.

The idea, he says in the General Catalogue description, is "to promote careers in the development and implementation of policies for the productive use and control of technology" . . . restraints on toxic chemicals . . . energy conservation . . . recycling . . . international marine resources . . . policies to foster innovation.

Qualified students from any department in the School of Engineering can sign up, and 25 have done so for the Program's first year, beginning this fall.

All students in the Program will take a new subject on "The Policymaking Process" given by Martha Weinberg, Assistant Professor of Political Science, and all will attend a proseminar on projects and case studies in actual policy problems. The rest of their time will be divided about equally between subjects in engineering and science and those in the social sciences.

Civil Engineering

R. Foott

C. C. Ladd

R. C. Jones

M. P. O'Brien

E. P. Popov

S. N. Singh

Honors at the A.S.C.E.

Members of the M.I.T. community claimed four major honors at the 1976 convention of the American Society of Civil Engineers in Philadelphia at the end of September:

The Norman Medal — the A.S.C.E.'s "oldest and most prestigious award," was given to **Roger Foott,** Sc.D. '73, and **Charles C. Ladd,** Sc.D. '61, Professor of Civil Engineering, for their paper on a "New Design Procedure for Stability of Soft Clays."

Egor P. Popov, S.M. '34, Professor of Civil Engineering at the University of California, Berkeley, received the Ernest E. Howard Award for contributions to the advancement of structural engineering; the results of his extensive research spanning four decades "are used widely in the design of modern structures," said the citation.

The Alfred Noble Prize for a technical paper of "exceptional merit" was given to **Shri N. Singh,** Sc.D. '68 (Metallurgy and Materials Science), for a technical paper in the field of steelmaking.

Honorary Membership in A.S.C.E. — the Society's highest honor — was presented to **Morrough P. O'Brien,** '25, former Dean of the College of Engineering at the University of California, Berkeley. Through "innovative and distinguished" contributions, Dr. O'Brien put the discipline of coastal engineering on a "quantitative rather than a qualitative basis," said the citation.

Russel C. Jones, a former member of the M.I.T. faculty who is now Chairman of the Civil Engineering Department at Ohio State University, was installed during the meeting as Vice President — Zone II — of A.S.C.E.

Robert C. Ruhl

Gordon Powell

A. V. Oppenheim

P. A. Wolff

II
Mechanical Engineering

With the Alumni

David Anderson, '64, is the new owner of James Smith and Son, Inc., manufacturers of precision grinding equipment and wire twisting machinery, Worcester, Mass. . . . **C. Fredric Young,** S.M. '60, has been elected vice president of operations for Towle Silversmiths of Newburyport, Mass. . . . **Gregory F. Zaig,** S.M. '72, now is Manager of Engineering Administration of the Artificial Organs Division of Travenol Laboratories . . . **Loren S. Bonderson,** Ph.D. '72, took a leave of absence last year from General Motors to hold the position of visiting professor in mechanical engineering at Arya Mehr University of Technology in Tehran, Iran . . . **Rodney I. Frost,** '52, is Manager of Mechanical Product Development for Corning Glass Works, Corning, N.Y.

Robert F. White, '51, is Director of Manufacturing, a new position at General Dynamics' Electric Boat Division, Groton, Conn.

III
Materials Science

With the Alumni

Louis T. Kiss, S.M. '69, was adviser on the application of scanning electron microscopy to materials examination for U.N.I.D.O. at the Marmara Research Institute, Turkey, in 1975 . . . **Kenneth M. Ralls,** Sc.D. '62, Associate Professor of Mechanical Engineering at the University of Texas at Austin, and **John Wulff,** Professor Emeritus in the Department of Materials Science at M.I.T., co-authored the recently published college text, *An Introduction to Materials Science and Engineering* . . . **Robert C. Ruhl,** Ph.D. '67, is now Vice President of Engineering for Chase Brass and Copper Co., Inc., a subsidiary of Kennecott Copper Corp., in Cleveland, Ohio.

Edward Epremian, '43, has left his position at Union Carbide Corp. in New York City to be Executive Director of the National Research Council's Commission on Sociotechnical Systems, the agency which studies the effects of large-scale technological systems that provide goods and services to the public . . . **William R. O'Day, Jr.,** '67, has left Banco Lar Brasileiro in Rio de Janeiro to be staff assistant of the Process Machinery Division of Rexnord, producers of mechanical and hydraulic power transmission components and other specialized machinery, located in Milwaukee, Wisc. . . . **Gordon Powell,** '51, Professor of Metallurgical Engineering at Ohio State University, participated in a special research-in-industry project at the Palo Alto Laboratories of Lockheed Missiles and Space Co. designed to relate college course material to students' future career needs.

The Real Limits to Growth

When Herman Kahn and two Hudson Institute colleagues finished *The Next 200 Years* (it's an optimistic answer to the pessimistic *Limits to Growth* by Dennis L. Meadows, Ph.D. '69, which reports his Club of Rome study performed at M.I.T.), the publishers called together a symposium as a way of publicizing the new book. "Growth" and "no-growth" arguments flew across the podium almost without end, until Charles A. Zraket, S.M. '53, Senior Vice President of MITRE Corp., introduced a hard-headed engineering outlook: "There is an explosive growth of infrastructure behind (Dr. Kahn's) scenario — transportation, communication, oil and coal production — in the next 25 years," he said. "The resources of Mother Nature are not a problem — the question is how fast we can build what we must."

Green Professorship in Course VI

Alan V. Oppenheim, '61, will be the Cecil H. Green Professor of Electrical Engineering for two years beginning this July. It's both an honor and an opportunity; in 1970 when Cecil H. Green, '23, and Mrs. Green established the chair they said they wanted it to give faculty "a chance to move into new areas of research."

Professor Oppenheim's present research is on digital signal processing and its application to speech and visual images. He wants to extend this into related areas of control theory, digital technology, and seismic signal processing. Professor Oppenheim has been at M.I.T. ever since receiving his Sc.D. in 1964 except for a one-year Guggenheim Fellowship at the University of Grenoble, France (1972-73).

Professor Oppenheim follows Professor Richard B. Adler, '43, in the Green Professorship, which Professor Wilbur B. Davenport, Jr., Sc.D. '50, Head of the Department, says has "fulfilled a vital function . . . by making it possible for faculty in mid-career to reorient their research interests." Professor Oppenheim's S.B. and S.M. degrees were in Course VI-A — the "cooperative" program with industrial practice interspersed with academic work; so was Mr. Green's degree — 38 years earlier.

Found: A New Director for R.L.E.

The search began nearly a year ago, when Professor Henry J. Zimmermann, S.M. '42, announced that he wanted to give up the job of directing M.I.T.'s pioneer interdepartmental Research Laboratory of Electronics.

It ended last summer with the naming of Professor Peter A. Wolff, a relative (1970) newcomer to the Department of Physics who has headed its Solid-State and Atomic Physics Division. Dr. Wolff has also been Assistant Director of the M.I.T. Center for Materials Science and Engineering since March, 1974; and he'll relinquish both those jobs to become Director of R.L.E.

Dr. Wolff came to the Physics Department from Bell Laboratories, where he had worked since 1952 on semiconductors, light scattering, and nonlinear optics and directed a large optics-oriented research group. His degrees (A.B. 1945, Ph.D. 1951) are from the University of California (Berkeley).

Dr. Wolff says he will appoint Associate Directors of R.L.E. from the major areas of the Laboratory's research — general physics, plasma dynamics, and communication sciences. R.L.E. attracts the involvement of about 100 faculty members, up to 300 graduate students, and 100 undergraduates.

Jonathan Allen Completes R.L.E. Team

Jonathan Allen, Sc.D. '68, Professor of Electrical Engineering, is now Associate Director of the Research Laboratory of Electronics. He'll work with Professor Peter A. Wolff (Physics), new Director of R.L.E., with responsibilities in engineering and communications sciences; and he has a special assignment to strengthen ties between the engineering and linguistics groups in R.L.E.

R.L.E. is M.I.T.'s first interdepartmental laboratory, and it's often regarded as a model for such interdisciplinary efforts in the university environment. Professor Allen studied at Dartmouth before coming to M.I.T., and for two years before joining the Institute faculty in 1968 he was Supervisor of Human Factors Engineering at Bell Telephone Laboratories. His M.I.T. research is in the field of speech processing and conversion.

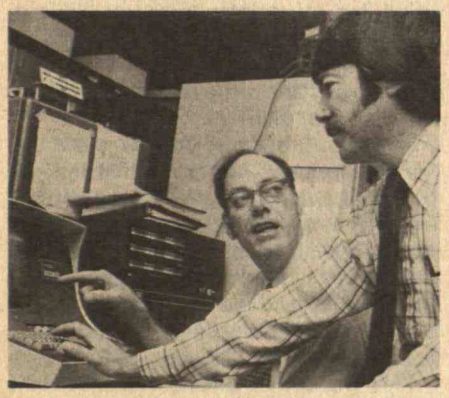
After entertaining them at luncheon in Dallas this summer, Cecil H. Green, '23, describes the seven Course VI-A students on summer assignments at Texas Instruments, Inc., as "certainly a great lot . . . very bright and gifted." A little more than 50 years ago Dr. Green was such a student, and seeing his successors "made me proud all over again," he wrote to John A. Tucker, Director of the VI-A Program. In the picture, left to right: (seated) William R. Bidermann, '76, Dr. Green, Mr. Tucker, and Dennis J. Meyers, '78; (standing) James Cherry, '78, Robert M. Asher, '78, Eduardo M. Moncada, '78, Giles A. Pauli, '78, and Keith A. Blanton, '78. (Photo: Texas Instruments, Inc.)

Making Words Into Digits, and Vice Versa

Most communication systems of the U.S. Air Force have gone digital, and now John E. Roberts (*left, below*), S.M. '56, and his associates at MITRE Corp. are helping to complete the transaction with a new, highly efficient digital voice communication system.

The self-contained system converts speech into digital form — a series of Os and Is — for transmission and reconverts the digital signals into synthesized speech at the receiving end. Algorithms devised by Mr. Roberts and his associate Richard H. Wiggins (*right, below*) make possible rapid communication; the algorithms, stored in the memory in the digital terminals, reduce by nearly half the computation previously required to achieve voice-to-digital and digital-to-voice conversions.

Mr. Roberts lists the advantages which have led the Air Force to turn increasingly to digital communication systems: minimal power requirements, less interference, increased efficiency, and higher security.



A Hunsaker Professorship in Space Colonies

Gerard K. O'Neill, Professor of Physics at Princeton University whose proposals for satellite solar power systems and space colonies utilizing lunar resources have won wide public attention, is Jerome Clarke Hunsaker Professor for the current year.

Professor O'Neill is conducting a seminar on advanced concepts for space utilization, and many student and faculty activities are being organized around his interests. Further reports will appear in the *Review* as these activities develop during the year.

Green Professors: Brace and Wunsch

The two new professorships in the earth sciences endowed last spring by Dr. and Mrs. Cecil H. Green have now been awarded to Professors William F. Brace, '46, a leading scientist in the field of rock mechanics and structural geology whose work has helped open the way to earthquake prediction, and Carl I. Wunsch, '62, a distinguished oceanographer known for studies on waves, tides, and ocean mixing processes.

The Greens' gift to the M.I.T. Leadership Campaign establishing the two Cecil and Ida Green Professorships was a $3 million addition to their giving to the Institute; there are three earlier professorships in the earth sciences, electrical engineering, and engineering education; a series of fellowships — primarily for women — in the Graduate School, and the gift which gave the Greens' name to the earth sciences building more than a decade ago.

Dr. Green, who studied electrical engineering in the Class of 1923, was cofounder of Geophysical Services, Inc., the predecessor company to Texas Instruments, Inc., which he now serves as Honorary Director.

Green Professorship to Feshbach

Herman Feshbach, '42, Head of the Department of Physics, is Cecil and Ida Green Professor of Physics, the first occupant of the professorship endowed early this year by Dr. and Mrs. Cecil H. Green of Dallas, Tex.

Dr. Feshbach, a distinguished nuclear physicist, has been Head of the Department since 1974; a year earlier he won the Tom W. Bonner Prize of the American Physical Society for contributions to the theory of nuclear reactions and to experimental methods for their analysis. He's taught physics at M.I.T. since 1941, having first come to the Institute in 1937, and he's been a member of the faculty since 1945.

IV
Architecture

With the Alumni

John B. Davidson, M.Arch. '71, is with Interbase, Inc., Toronto, which he describes as a "national multidisciplinary transportation and land use planning, urban design, architectural, and engineering firm." . . . **Ann M. Kidwell,** M.Arch. '72, is now a licensed architect in the state of Texas, having passed the national architectural licensing examinations late last year; to celebrate she traveled to Mexico to study Mayan architecture in February and this summer cruised among the "tall ships" off Newport. . . . **John S. Reynolds,** M.Arch. '67, Associate Professor of Architecture at the University of Oregon, won that school's $1,000 Ersted Award for Distinguished Teaching last June. He teaches architectural design and environmental control systems; of the former, the citation said, "He has taken what often is a rather dry and technical subject and helped make it one of the most important in the School." Dean Robert Harris says that Professor Reynolds' course on environmental control systems is one of the few in the nation that is "really good."

Bernard P. Spring, M.Arch. '51, Dean of the School of Architecture at C.U.N.Y., offers a list of professional assignments: consultant to A.I.A. Research Corp.'s "Energy-Conscious Design Program," Chairman of the Harrison, N.Y., Architectural Review Board, Consultant to the Department of Housing and Urban Development, and member of the New York State Board for Architecture.

VI
Electrical Engineering

Course VI-A alumni have a special fellowship all their own, and it came to the fore late last summer when John A. Tucker, Director of the VI-A Program, visited the San Francisco area.

There were parties in his honor in Sunnyvale (on August 8 with **Edward C. Gialmo,** '74, as host) and Cupertino (on August 14 with **Allen J. Baum,** '74, host). Among those attending were seven M.I.T. students then on work assignments at Hewlett-Packard Co. and I.B.M. Corp. — the first summer that a VI-A student had been at I.B.M.'s San Jose laboratories — and eight VI-A graduates: **C. Mel Aden,** '74 (H-P Co.), **Allen J. Baum,** '74 (H-P Res. Labs., Palo Alto); **Robert M. Colopy,** '74 (Hughes Aircraft Co., Los Angeles — currently at Stanford on a Hughes Fellowship); **John F. Cooper,** '74 (H-P Stanford Park Div., Palo Alto); **Sherry R. Grobstein,** '74 (H-P Medical Prod. Group, Waltham, Mass., then on special assignment at H-P's Stanford Park Div.); **Wendy Pelkes,** '76 (H-P Data Systems, Cupertino); **Susan A. Thomas,** '76 (Intel Corp., Santa Clara), and **Kenneth A. Van Bree,** '71 (VI-A Coordinator at H-P Res. Labs., Palo Alto).

VII
Life Sciences

Christopher T. Walsh (biochemistry and bioorganic chemistry, a joint appointment with the Department of Chemistry) and **Robert A. Weinberg,** '64, (Center for Cancer Research) have been promoted from Assistant to Associate Professor.

With the Alumni

Colonel **Charles H. Beckmann,** '52, U.S.A.F., is Chief of the Cardiology Service in the Department of Medicine, Wilford Hall U.S.A.F. Medical Center, Lackland Air Force Base, Texas. He's been at Wilford Hall since 1973, first as Chief of Internal Medical Services; and he's Clinical Assistant Professor of Medicine at the University of Texas. . . . **June R. Scott,** Ph.D. '65 has been promoted to Associate Professor of Microbiology at Emory University. . . . Since 1971, when he left Monsanto, **Richard S. Gordon,** Ph.D. '54, has been serving as Visiting Professor at Washington University, "almost overwhelmed by requests to do consulting . . . and slowly reentering a life devoted to research and teaching."

VIII
Physics

Claude Cohen-Tannoudji and **Dieter Zimmermann** are completing their work at M.I.T. as Visiting Professors of Physics. Dr. Cohen-Tannoudji, a member of the faculty of the College de France, Paris, is a specialist in the interaction of radiation and matter. Dr. Zimmermann's M.I.T. assignment was in connection with the exchange program between the Institute and the Technical University of Berlin, where he is Professor of Physics in the Institute for Radiation and Nuclear Physics.

Min Chen, whose field is experimental high-energy physics, has been promoted from Assistant to Associate Professor.

C. F. Fitter

With the Alumni

Charles F. Fitter, '40, designed the Grand Central Colorama for Eastman Kodak Co. in 1950; since then he's been in the International Sales Division holding world-wide assignments for photofinishing products and for establishing color finishing laboratories. Now he's been promoted to the Assistant to the General Manager of Kodak's Asian, African, and Australasian Region. . . . Having reached the age of 70, **Rene J. Marcou,** Ph.D. '33, has retired from his post as Professor of Research at Boston College; he retired from teaching in 1972, having been a member of B.C.'s mathematics faculty since 1947. . . . **Joseph Morgan,** Ph.D. '37, has returned to full-time teaching and research as Professor of Physics at Texas Christian University; before January, 1976, he was Director of Research Coordination at T.C.U., and he's also been Chairman of the Physics Department and Vice President of T.C.U.'s Research Foundation.

Carter's Economic Education

"Jimmy who?" asked Lawrence R. Klein, Ph.D. '44 — just like the rest of us — when he was asked to sign on as head of the Democratic candidate's economic task force a year and more ago.

But Dr. Klein — he is President-Elect of the American Economic Association, a distinguished specialist in econometrics on the faculty of Pennsylvania's Wharton School — finally agreed, and then he went to work assembling a task force which prepared materials to be processed into speeches and longer "position papers" for Governor Carter's campaign.

As the Democratic Convention ended last summer, the Washington Post *News Service assembled a report on Dr. Klein and his activities. Here are excerpts:*

Although one of the nation's most productive economists — some say he's only a chip shot away from a Nobel Prize — Klein until now has eschewed the government-policy side of economics, preferring to stay on the academic side.

But he has helped put together — and now heads — a diverse economics team that numbers 16 ranging from an economist rated by some as ultra-liberal (Lester Thurow of M.I.T.) to a conservative (Martin Feldstein of Harvard).

"Carter likes to come at something from 360 degrees," Klein said in his plain, almost austere office at the Wharton Econometric Forecasting Associates, a non-profit consulting service he runs along with teaching assignments. "Mr Carter wants to get all of the facts."

And so, the economic education of Jimmy Carter got under way in earnest during the summer of 1975, first with papers prepared by Klein, and then at a long meeting among Carter, Klein and Albert T. Sommers of the Conference Board.

At the beginning, Carter wondered whether both inflation and unemployment rates could be cut to 2 per cent. Now, of course, under the tutelage of the Klein task force, the Carter goal is a more vaguely defined "full employment with price stability," the target being a jobless rate of 4.5 per cent or so within three or four years.

"At one of the early meetings," Klein reminisced last week, "Carter asked how low unemployment and inflation could go, and what the best targets would be.

"And then he said to me, 'I think unemployment is going to be a real issue in this campaign.' I agreed, and we discussed policies to alleviate unemployment. At that time, he first put forward his belief that much can be done through the private sector."

Ever since, Carter has listened very carefully to Klein's special brand of cautious, Democratic liberalism, laced with the mathematical reliance on models that typifies the econometric approach.

Lawrence R. Klein

Too Focused on His Models?

His peers among economists rate Klein highly, emphasizing that he is "moderate" and "a good listener." Most are frankly surprised by the vigor with which he threw himself into the Carter campaign.

Equally, they are impressed by the degree to which Klein has Carter's ear. According to insiders, Klein is only one of two men outside the original "Georgia group" to whom Carter pays undivided attention.

If there is a worry that some economists have about Klein, it is the tendency of econometricians to rely exclusively on their "models," and ignore what some feel is "the real world" of financial markets.

Klein is generally regarded as preeminent in the field of econometrics. He constructed the famous Wharton model, which many corporations and government agencies use to help forecast the future. Lately, critics such as Federal Reserve Chairman Arthur F. Burns have concluded that the econometric models are overly simplistic, and a poor substitute for the subjective judgment of informed and experienced economists.

That cuts little ice with Klein. He concedes econometric devices may have to be refined, but believes that economists will in the future have to use even more sophisticated analytic tools. In addition, he sees the need for more emphasis on "micro-economic" problems, (the specifics, as opposed to the "big picture") and attention to the "supply" side of the economy as well as the "demand" side.

A future Economic Council, Klein believes, will have to pay as much attention to problems like agriculture, energy and the environment as to the broad fiscal-monetary questions that he feels now preoccupy it. He has therefore asked economist Gary Fromm of the National Bureau of Economic Research to prepare a paper on how to restructure the Economic Council.

Klein was born in Omaha, educated at the University of California, and got his Ph.D. from M.I.T. at the age of 24 with a mathematical interpretation of John Maynard Keynes' "General Theory," still the definitive work on the subject.

He has taught at the University of Michigan, and came to the University of Pennsylvania in 1958, where he now is the Benjamin Franklin professor of economics.

Killian Faculty Achievement Award To Teuber

Hans-Lukas Teuber, Head of the Psychology Department since its founding in 1964, holds the 1976-77 James R. Killian, Jr., Faculty Achievement Award. As winner, he receives a $5,000 honorarium, and he will give two public lectures — on January 12 and 19 — for the Institute community.

The Killian Award citation notes that Dr. Teuber "never ceases to support, by precept and example, his three-fold ends: informed observation, keen experimentation, and generosity and wit to make the fruits of science available to all. . . . He displays two high gifts — that of a scientist's perpetual wonder at the mysteries of brain and behavior, and that of the artist's compassion for the springs of thought and action in his fellow human beings."

Professor Teuber came to M.I.T. in 1961 from the Bellevue Medical Center in New York, where he had set up and directed a pioneering head-injury research unit. He has continued this work at M.I.T., and the Killian Award citation notes his "standards of conceptual breadth and logical rigor in the experimental study of the deficits produced by brain wounds in perception, cognition, language, and memory."

With Dr. Teuber in the picture above are (left) President Jerome B. Wiesner and (center) James R. Killian, Jr., '26, Honorary Chairman of the Corporation, whom the award honors.

Certain Future for Urban Studies Graduates

The Department of Urban Studies at M.I.T. now has a positive answer for prospective students who ask, "What can I do with a degree in urban studies?"

A survey of those who graduated between 1971 and 1975 — the Department's undergraduate program has only five years of M.I.T. history — proved that its graduates are trained for a certain, but not economically striking, employment future. The S.B. degree has been a stepping stone to a variety of careers, represented most heavily by urban planning, law management, and medicine. The survey's "snapshot" of urban studies graduates in the spring of 1976 also showed:

— Of the 55 respondents (66 per cent of the total graduates), 36 were employed, 28 were in school, and one was unemployed. Of those presently employed 12 are working as planners; a similar number are policy analysts, researchers, or consultants; four are lawyers or doing para-legal work; and the remainder are in unrelated categories. Of the total, only eight — all without advanced degrees — experienced one period of over three months' unemployment. This rate compares favorably with bachelor's recipients in other fields, thinks Dr. Robert Hollister, Assistant Professor and Director of the Undergraduate Urban Studies Program.

— Though graduates had little difficulty finding "responsible and interesting" positions in both public and private sectors, most alumni, 80 per cent, sought advanced degrees — 60 per cent did so immediately after graduating.

— Salary levels were "reasonable" in first full-time employment, averaging $10,250 for S.B. graduates; those 60 per cent who went on to receive advance degrees averaged $13,600. Though the program is too young to generalize salary increases over time, the average salary showed a "healthy" increase to $15,400 for 1971 graduates, $13,000 for 1972 graduates, and $16,300 for 1973 graduates.

Individual areas of concentration, fieldwork, and curriculum flexibility were cited by alumni as the most valuable aspects of the urban studies program.

XI

Urban Studies and Planning

Community Fellows

Some 40 urban-related professionals have studied at M.I.T. as Community Fellows since 1971, and most of them are now back in minority community organizations working on projects which have grown out of their M.I.T. experience. Now nine new fellows are in residence this year:

Baha U. Abdul-Malik, Director of Biosphere and Hydrosphere Associates, Seattle, a firm devoted to marine science and technology transfer ventures.

Irma Castro, Lecturer in Mexican-American Studies at San Diego State University.

Joseph M. Conrad, Director of the Office of Government and Industry Relations of the U.S. Small Business Administration.

Luz E. Cuadrado, Executive Director of Inquelinos Boricuss en Acion, Boston, a community development corporation engaged in rehabilitating a 40-acre area in the South End.

Robert C. Hayden, Managing Director of Project Torque at the Education Development Center, Inc., Newton, a program to develop school achievement tests in mathematics for testing at five schools in the U.S. and Puerto Rico.

Walter R. Huntley, Jr., Special Assistant to the Mayor of Atlanta, Georgia.

Alvina R. Kelly, Staff Assistant to the Regional Administrator of the U.S. Public Health Service, Boston, where she is Equal Employment Opportunity Officer.

Vivien Li, Project Director, Air Quality — Transportation Control, City of Newark, N.J.

Nobuko Narita, Executive Director of Collective Black Artists, Inc., New York City, an organization devoted to bringing the work of black artists — especially musicians — before the public.

While at M.I.T. for the year, each of these Fellows will work on a program or plan to be applied upon their return to their organizations and communities.

M. H. King

Now It's Professor Melvin King

Melvin H. King, a leader of the Boston minority community who has been a member of the Massachusetts legislature representing the Fourth Suffolk District since 1973, is now Adjunct Professor in the Department of Urban Studies and Planning.

Mr. King has been Lecturer in the Department since 1971, serving as Associate Director of the Community Fellows Program which brings minority community and government leaders to M.I.T. for research and study. As Research Associate during the same period, Mr. King has been working closely with the M.I.T. Urban Systems Laboratory.

XII
Earth and Planetary Sciences

John S. Dickey, Jr. (petrology and tectonics) and **Christopher Goetze** (mechanical properties and deformation of rocks) have been promoted from Assistant to Associate Professors.

With the Alumni

James L. Powell, Ph. D. '62, who was named Provost a year ago, has now been named Vice President and Provost of Oberlin College. He was Associate Dean of Oberlin's College of Arts and Sciences for two years before 1975, and he continues as Professor of Geology on the faculty which he first joined in 1962. . . . As Assistant Professor of Geology in Erindale College of the University of Toronto, **Robert M. Stesky,** Ph.D. '75, is a member of the University's School of Graduate Studies.

XVIII
Mathematics

Richard B. Melrose, who was Visiting Scientist in the Department under a grant from the United Kingdom Science Research Council in 1974-75, has now joined M.I.T. as Assistant Professor. Dr. Melrose was a Fellow of St. John's College of Cambridge University last year, where he received his Ph.D. in 1974; his special field is partial differential equations.

Two Visiting Professors are at M.I.T. in mathematics this fall: **Michael B. Woodroofe** is Professor of Mathematics and Statistics at the University of Michigan; and **Glenys L. Luke** (she is Visiting Associate Professor) is a Fellow of St. Hugh's College and Lecturer in Mathematics at Oxford University.

With the Alumni

Two alumni in the news at Lehigh University: **Robert F. Barnes, Jr.,** '57, Head of the Division of Information Science within the Department of Philosophy, is full Professor; and **Bennett Eisenberg,** Ph.D. '68, is Associate Professor of Mathematics, with tenure. . . . **David I. Caplan,** '51, formerly Director of Engineering and Programming for Raytheon Data System Co., is Vice President — Engineering at Inforex, Burlington, Mass.

XIX
Meteorology

Glenn R. Flierl, who finished his Ph.D. at Harvard in physics in 1975, has joined the Department as Assistant Professor; he'll be in charge of the subject in Physical Oceanography — an introductory presentation of the physics of the oceans — this fall. . . . Another new arrival is **David A. Randall,** whose Ph.D. will be awarded later this year at the University of California (Los Angeles); as Assistant Professor he'll work in weather prediction and atmospheric dynamics.

With the Alumni

Don G. Friedman, Sc.D. '54, is Director of the Corporate Planning and Research Department, the Travelers Insurance Companies, Hartford, Conn.; he's an applied meteorologist specializing in the assessment of natural hazards.

McNees: Applying Hindsight to Economic Forecasters

Economic forecasters have had a bad five years since 1970 — a period of mild recession coupled with inflation followed by an unpredictable oil embargo, an unpredicted severe "staflation," and finally a predictable recovery. The forecasters' errors were "unprecedented in magnitude," says Stephen K. McNees, Ph.D. '70, Assistant Vice President and Economist at the Federal Reserve Bank of Boston. Forecasting the forecasters, Dr. McNees now thinks future forecasts are likely to be better — "at least temporarily."

Dr. McNees' reviews of the economic forecasters' fortunes appear regularly in *New England Economic Review,* published by the Federal Reserve's Research Department. His report is based on five influential economic reports — those of the Bureau of Economic Analysis (Department of Commerce), Chase Econometric Associates, Inc., Data Resources, Inc., Wharton Econometric Forecasting Associates, Inc., and the American Statistical Association/National Bureau of Economic Research.

The forecasters began 1970 on the wrong foot because of "the unexpectedly strong growth in the civilian labor force." Thus unemployment rates were persistently higher than they expected. So was the rate of inflation, on which the forecasters would have been wrong but for the imposition of wage-price controls in 1971.

Then came President Nixon's "New Economic Policies" in August, 1971, and forecasts of their effects "must be regarded as an overwhelming success," despite "several simultaneous and unprecedented policy shifts." But the honeymoon was short-lived; though the forecasters were aware of Middle Eastern tension, they did not foresee the oil embargo and the sharp rise in the cost of energy which it precipitated.

As a result, forecasts for the year beginning in October, 1973, overestimated real growth by 4.2 to 5.5 per cent and underestimated inflation by 5.1 to 6.1 per cent. These "unprecedented" errors "provided a very poor indication of where the economy was headed," says Dr. McNees.

The troubles continued. By January, 1974, forecasters were proposing that the economy was "suffering from a short-lived energy spasm," and growth would soon resume. Employment remained high — perhaps due to hoarding because employers expected growth to resume. But productivity collapsed and real output was overestimated; "the upward pressure on prices and downward pressure on output" were stronger than expected, and in their "post-embargo euphoria" the forecasters failed completely to warn of the unexpected recession of 1974-75, failing especially to expect the high unemployment rates of early 1975.

The error in output began when forecasters failed to foresee the slow-down in 1975 auto sales, which Dr. McNees attributes to pollution control and safety equipment and to sharply increased prices. Financial stringency made an unexpected impact on both prices and output.

Now the economy has — at least temporarily — recovered from these aberrations, and Dr. McNees thinks "forecasting-errors may return, at least temporarily, to more normal magnitudes." — *J.M.*

A Sloan Fellow Describes His Route from Music to Technology to the Top

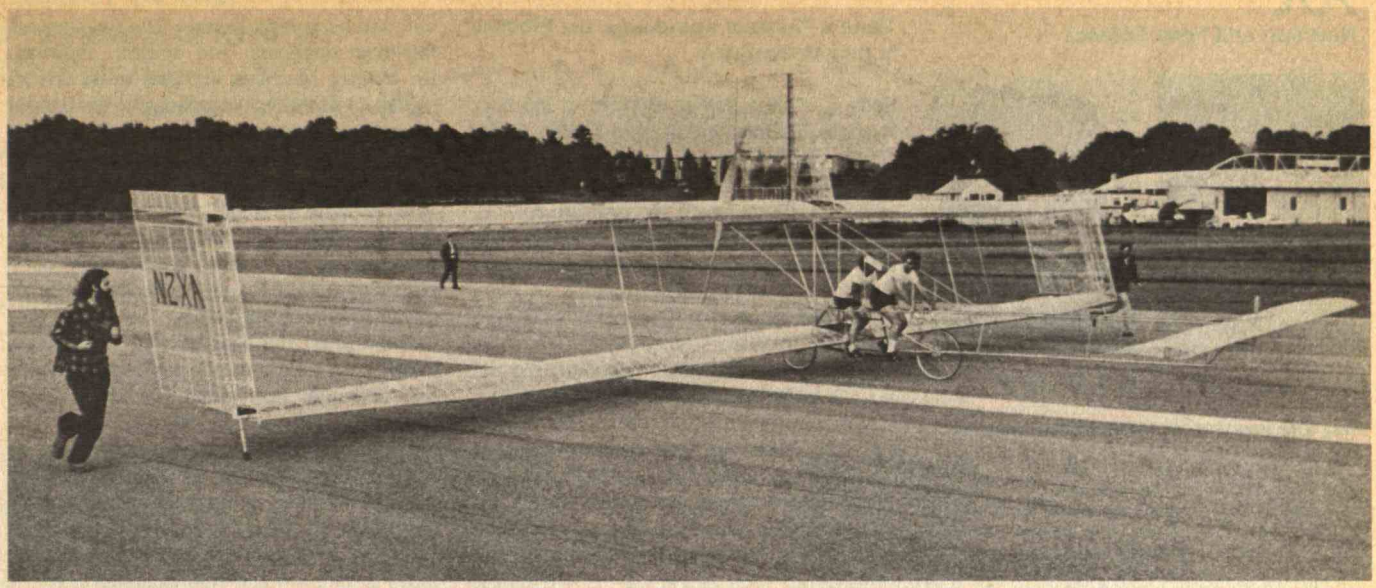
To his new job as Managing Director of Japan's Sony Corp. in Germany, where Sony has just taken over Wega-Radio as a subsidiary, Gerhard Schulmeyer, S.M. '74, brings an unusual combination of talents: he is musician, engineer, and manager.

Mr. Schulmeyer's first interest was music — a church trumpeter, conductor of choirs, and producer of recorded sacred music, and wanted to enter a conservatory to become a choir-master following his apprenticeship in electrical work at Braun, a German Gillette subsidiary.

But Braun tempted the deserter back with a grant and trained him in what Mr. Schulmeyer now calls "the profane business of engineering," shortly setting him to work in electronic research and development related to high-fi products and their production.

Then came a diploma in world trade from the Frankfurt Academy for World Trade and new ambitions for an ascent into top management by age 40. M.I.T.'s Sloan Fellowship Program provided "the consecration of an elite school" — just what Mr. Schulmeyer saw himself as needing. The result was an assignment for Gillette, Braun's owner-conglomerate, as manager for hair-spray products. But by 1975 Mr. Schulmeyer — with "proven versatility and international background" — was ready to return to consumer electronics, and the timely offer from Wega-Radio was just what he wanted.

Sony in Germany will not exist in the shadow of its parent company, says Mr. Schulmeyer. "We want to participate in Sony's technical know-how to the full and nevertheless remain independent. If this were not so I would not have taken the job."



Chasing the Elusive Dream of Man-Powered Flight

Remember BURD — the ill-fated student-designed man-powered aircraft which was to take aim at British industrialist Henry Kremer's $75,000 prize for the first man-powered craft to fly over a one-mile course?

BURD-1's career ended in a structural failure during a high-speed taxi test in April, 1974. Now there's BURD-2 (*B*i-plane *U*ltra-light *R*esearch *D*evice), a 124-pound successor which "came through initial testing with flying colors" during the fall, according to Professor Eugene E. Covert, Sc.D. '58. With luck and good weather, there may be a flight early in the spring.

BURD-2 is powered by a modified bicycle chain drive operated by two riders who sit in tandem just forward of the leading edge of the lower wing; the pedal drive turns the craft's rear wheel and the rear-mounted ten-foot propeller. Construction is of polystyrene foam, graphite fibers, balsa wood, aluminum tubing, and polypropylene. Whether it flies or not, Professor Covert is enthusiastic: BURD-2 is "one of the greatest educational aids to young engineers I've ever seen," he told *Tech Talk* last fall. (Photo: Calvin Campbell)

Keeping "Gustatory Delights" on Tomorrow's Grocery Shelves

Eleven trends in the future of the food industry, says Samuel A. Goldblith, '40, Underwood-Prescott Professor of Food Science:

☐ Increasing use of radio-frequency energy in food processing; extensive use in sterilization, he says, depends on the development of accurate r-f energy controls and of integral nonmetallic containers.

☐ Increasing use of computers throughout the food industry, to optimize process control, manage inventories, increase efficiency, and maintain accurate databanks on batches and lots.

☐ Growing acceptance by consumers of thermally-processed pouch-packed foods — especially because of demographic trends to smaller families.

☐ De-emphasis of food "additives." Professor Goldblith insists that "the food additives situation is (not) anywhere near as bad as the vocal minority claim," but he believes "alternative equipment and processes" will reduce the need for special materials.

☐ Reduced food costs due to higher productivity in the industry — "an area where much more needs to be done." This will be accomplished, at least in part, by new production systems — continuous, automatically controlled factories, for example.

☐ Improvements in soybean technology. A better understanding of the "basic chemistry of the soybean," says Professor Goldblith, promises "a whole host of thermally processed products through which soybeans will extend our protein supply."

☐ More efficient use of energy in food processing, including the use of waste heat and of solar energy.

☐ Greater utilization of food processing wastes as animal feeds and fertilizers. Finally, says Professor Goldblith, "we may learn how to make our factories into ruminants."

☐ Emphasis on institutional products. "Eating away from home" is a growing trend, and "better products at lower prices are more achievable in the food factory than at the user establishment."

☐ Vertical integration of the food industry, "to achieve better quality and regular supply of raw materials."

☐ Increasing concern for substitute formulations as the prices of some food materials increase.

"The consumers of tomorrow will continue to demand convenience, quality, safety, economy, and gustatory delight in their food supply," Professor Goldblith told a Centennial Meeting of the American Chemical Society this year. The industry's response will be along the lines of these eleven prognostications which he said are "realizable in the lifetimes of many in this room." — *J.M.*

Scrimshaw Named Institute Professor

Dr. Nevin S. Scrimshaw, the distinguished expert on international nutritional problems who is Head of the Department of Nutrition and Food Science, has been named Institute Professor at M.I.T. It's an honor reserved "for scholars of special distinction, to recognize accomplishments and leadership of high intellectual quality" by members of the faculty, and it's bestowed by recommendation of a faculty committee.

Before coming to M.I.T. in 1961, Dr. Scrimshaw headed the Institute of Nutrition of Central America and Panama; he continues to work with I.N.C.A.P., and he teaches an M.I.T. field course in clinical and public health nutrition there. But his travels are world-wide — to Bangladesh on nutritional problems of refugees in 1971; to Southeast Asia on nutrition in North Vietnam and Laos in 1973; to Egypt, India, Pakistan, Bangladesh, and the Philippines for the Senate Subcommittee on Health in 1975; this summer for the World Health Organization, studying research and education in tropical medicine in Southeast Asia.

Few aspects of clinical and public health nutrition have escaped his expert interest and attention; his recent publications have related to human protein requirements and world resources for meeting them.

XX

Nutrition and Food Science

M. Milner

N. S. Scrimshaw

New Management for International Nutrition

The International Nutrition Planning Program (I.N.P.), a Rockefeller-funded research and training effort to help low-income countries increase food services and combat malnutrition, has two new directors: Dr. Nevin S. Scrimshaw, Head of the Department of Nutrition and Food Science, and Max Milner, Senior Lecturer in the Department.

Dr. Scrimshaw as Director and Dr. Milner as Associate Director of I.N.P. succeed F. James Levinson, who has now joined the State Department's Agency for International Development in Washington.

For six months ending last July, Dr. Milner was with the Food Program of the Office of Technology Assessment; he was formerly Scientific Secretary and Director of the Secretariat of the United Nations' Protein-Calorie Advisory Group, and he's had wide experience in the field of international nutrition.

With the Alumni

Hector Bourges Rodriguez, Ph.D. '68, Head of the Department of Nutrition, Physiology, and Food Technology in the National Institute of Nutrition (Mexico), is President of the *Asociacion de Tecnicos en Alimentos de Mexico* and Chairman of Section 26 of the Institute of Food Technologists (U.S.A.).

There's Plenty of Knowledge; the Problem is How to Spread It

Betty C. Hobbs, former Director of the Food Hygiene Laboratory in the British Public Health Laboratory Service, shares with Samuel C. Prescott, '94, and William Underwood an "enthusiasm for problem-solving," and it is the same enthusiasm that M.I.T. "has institutionalized to the enormous benefit of industries and people everywhere."

. . . the words of George C. Seybolt, President of William Underwood Co., at the luncheon when Dr. Hobbs was honored with M.I.T.'s 1976 Underwood-Prescott Award.

After 30 years in public health and nutrition work, Dr. Hobbs remains frustrated — not by our inability to solve problems but by our inability to communicate the results. People seldom pay foods more than gustatory attention, she said at the annual symposium in her honor at M.I.T. on September 28; the annual, post-holiday outbreaks of food poisoning demonstrate "our inability to teach the facts."

Microbiologists, food technologists, food engineers, and educators must together recognize that "hazard to health and keeping quality of foods are interwoven." But attempts at communication between these groups are usually "flimsy," Dr. Hobbs said.

She cited the salmonella story as a striking example of this communication gap. For years investigators blamed human sewage for the spread of salmonella, and for years the gut contents of cattle, pigs, and poultry — reservoirs of the disease-producing microorganism — continued to contaminate meat. The facts are now known, but the hazard still exists.

As more and more people are being fed from the large institutional kitches of schools, fast-food cafeterias, and airlines, explained Dr. Hobbs, so these kitchens must be designed "with the full knowledge of the danger of contamination from the raw to the cooked food. Better provisions for quick cooling and cold storage are required in all kitchens, whether large or small." The cost of prevention may seem high, she said, but not when compared to the cost of investigation, compensation, and lost working hours due to an epidemic of food poisoning.

Even when our food is free of disease-causing microorganisms, poor eating habits can endanger our health. Dorothy F. Hollingsworth, Director-General of the British Nutrition Foundation, says much nutrition education has the effect of advocating overconsumption. Eating standards established "to counteract the effects of poverty and deprivation result in obesity and heart disease given today's affluence and unathletic life style, she said. She wishes to see the facts of food function translated into terms of individual meals, so the public can more easily understand good nutritional habits.

Rose Marie Pangborn, Director of the Sensory Analysis Laboratory at the University of California at Davis, wants to know how our perception of food is related to our eating habits. Some poor habits, such as preference for foods with high levels of salt or sugar, could be due to innate properties in the individual's sensory system, she told the symposium audience. She speculated that one day we may find that some people who are obese due to overeating actually smell, taste, or feel food differently than those with no eating problems. — *Steven A. Rosenfeld*

This graduate of M.I.T.'s Sloan School of Management is now — among other things — co-author of the *Provincetown* (Mass.) *Advocate*'s summer gossip column. But that's not really out of character for Riva Poor, S.M. '71: she's a "change agent," a professional helper for people and companies that need the courage to change their lives or their ways of doing business; and she says the column is absolutely consistent with her "professional concern with lifestyles." (Photo: Karen Berman from the *Provincetown Advocate)*

Riva Poor and the Power of Change

While she was a graduate student in the Sloan School of Management, Riva Poor, S.M. '71, became famous as the advocate of the four-day work week and as author of *Four Days, Forty Hours.* That led to a series of consulting assignments with industries interested in the plan, and her sights gradually broadened as she saw the variety and character of people's and companies' problems. Now Ms. Poor describes herself as a "change agent . . . a catalyst in aiding companies and individuals to change their behavior and achieve their goals.

"Instead of helping people adjust to whatever miseries they're experiencing," Ms. Poor explained to Samuel Feinberg of *Women's Wear Daily* last summer, "I try to help them change either the situation they're in or their approach to handling problems. I teach them new ways of thinking about and doing things. Essentially I'm in the same business I've always been in — introducing innovations."

There are plenty of innovations in Ms. Poor's life to prove her understanding of the process. Her first M.I.T. degree was in city and regional planning; that led to work on how to increase minority groups' business opportunities. Then came her Sloan School degree and her advocacy of the four-day week. Finally, she realized that she was not really a business expert — she never had any management experience as such — but a decision-making expert. Hence her role as "change agent" — helping others (both individuals and businesses) understand their frustrations and change their lives to resolve them.

One example of Ms. Poor's success is Ms. Poor herself. She was a "workaholic," she says, before she learned her major passion: a love for Outer Cape Cod. She went to Provincetown as "an experiment in leisure," she told Karen Berman of the *Provincetown Advocate* last summer. She found she liked the life of tennis, swimming, and parties — "it took me about two days to adjust to leisure time," she recalled. Now she is a key member of the Provincetown summer colony, co-author of a weekly "happenings" column — "Summer Set" — in the *Provincetown Advocate.* It's all part of Ms. Poor's life plan: "I make a living doing what comes naturally," she told Ms. Berman, "butting in and making things work better."

Report of the President and the Chancellor

For the Academic Year 1975-1976
Massachusetts Institute of Technology

In our Reports of the past several years, four interrelated priorities have been emphasized: the search for a set of operating conditions to insure the long-term fiscal integrity of the Institute; support of the continued development and evolution of M.I.T.'s departments and laboratories; the development of more comprehensive and interrelated educational and research activities that contribute to the understanding of modern society and its humane and effective management; and enlargement of the growing intellectual role that more, and more varied, connections between M.I.T. and other organizations can play in the Institute's educational and research programs. In this Report we would like to discuss these issues explicitly and describe our view of how they affect the Institute and how they are affected by the setting in which the Institute functions.

These priorities are to some degree in conflict. For example, attainment of a stable set of financial operating conditions has required close attention to the growth of expenses and planned reduction of costs in most areas of Institute operations. We fully realize that continuing cost-control efforts can jeopardize the vitality of academic programs and essential support functions, and we have endeavored to maintain an appropriate balance between the intellectual needs of programs and the financial capabilities of the Institute.

Also, in a taut financial climate proposed new programs and existing activities inevitably compete for scarce resources. As a result, new programs are judged by criteria more stringent than those employed in the past, particularly with respect to the programs' ability to attract new resources. While the effect has in many respects been salutary, the shortage of venture capital, which slows down continued development and evolution in every field, tends to affect even the most dynamic and most promising activities. Even when a field happens to receive special national attention and thus somewhat more generous support for relevant research activities, as in the case of the Energy Laboratory, the development of associated new academic programs remains difficult to fund. Prudence clearly dictates an emphasis on the support of the vital core of the Institute. In the present situation we believe that it is necessary to concentrate more of our attention than just a few years ago on maintenance of the outstanding quality and enthusiasm of the faculties of the traditional groups, departments, and laboratories. This often involves the support of new intellectual ventures and we maintain a major commitment to recently-initiated programs, including the Center for Cancer Research, the Energy Laboratory, and the Harvard–M.I.T. Program in Health Sciences and Technology. These centers are now well established and contributing to the intellectual vitality of the Institute, to important national problems, and to the Institute's financial well-being. The Center for Policy Alternatives and the Division for Study and Research in Education are also on course in their development. We shall continue to seek ways to support other emerging, new activities of high quality that will become vital aspects of a future M.I.T.

Our efforts to achieve a satisfactory and lasting balance between operating expenses and revenues have led to the elimination of certain marginal activities, to broadly-based improvements in the efficiency and effectiveness of some operations, and to reductions in the level of activity of some essential support services. At the same time we have undertaken multiple efforts to increase recurring operating revenues. These efforts include a modest expansion of the size of both the undergraduate and graduate student bodies, increases in sponsored research activities, augmentation of the Industrial Liaison and M.I.T. Associates Programs, and the initiation 18 months ago of the Leadership Campaign.

We expected that cost control and income enhancement efforts, together with a lessening of the rate of inflation and improvement in investment income as the economy recovered from the recession would bring the budget back into balance. Although operating expenses for 1975-76 exceeded recurring revenues from all sources by approximately $2.6 million, this imbalance was, in fact, approximately 25 percent less than we had anticipated, and about half of the corresponding figure for the preceding year. Our present expectation is that the imbalance in operations will be reduced again in the year now beginning and that the operating budget will be at least in balance in the year that begins in July 1977. This progress has been helped substantially by the early results of the Leadership Campaign which has been gaining momentum over the past year; its success is an essential part of the Institute's economic health.

Our fiscal goal for the future can be stated in two parts. First, we must achieve a financial condition in which current

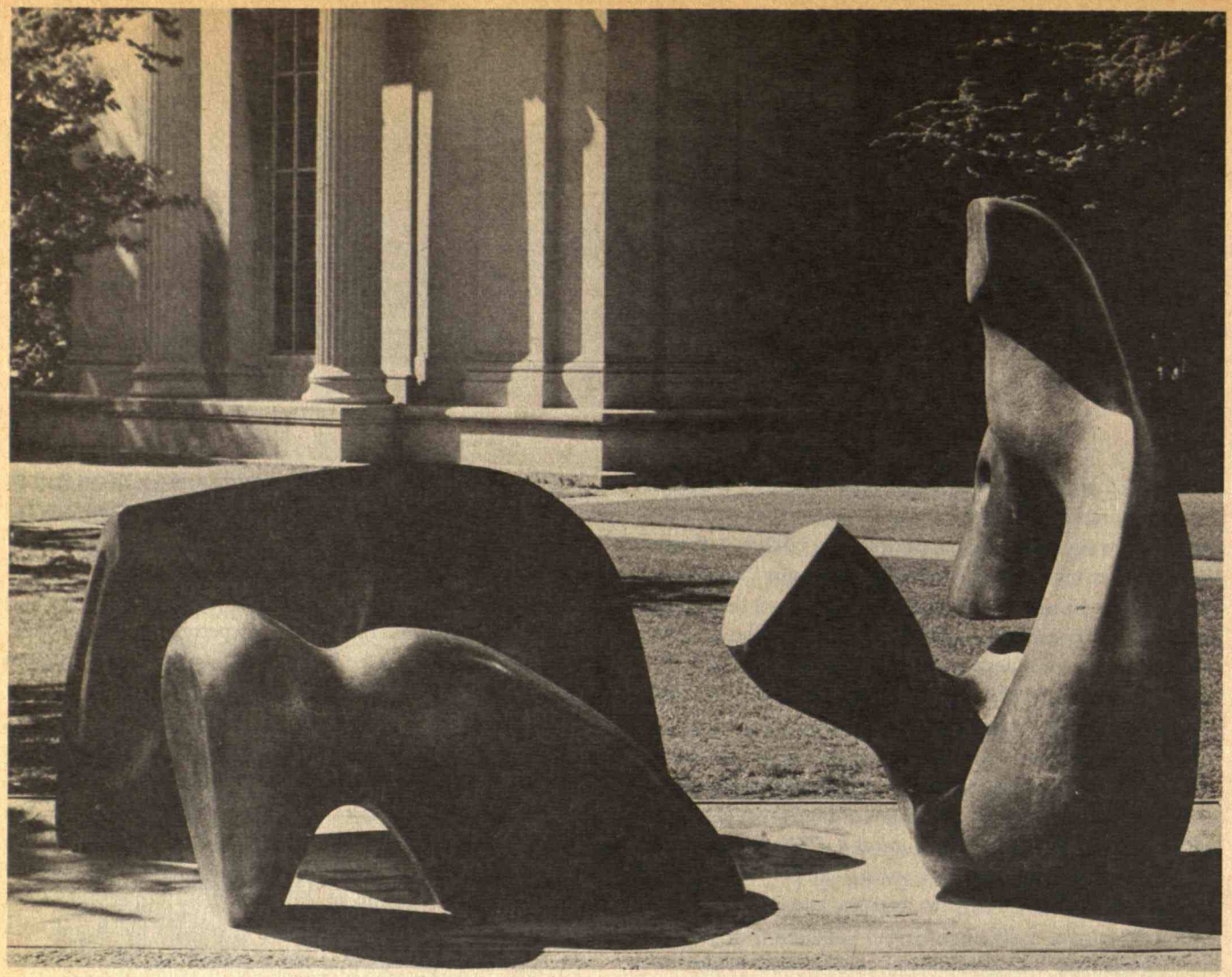
unrestricted gifts will not be committed primarily to support current operations, as they have been for the past four years, but will be available, at least in part, for the initiation of essential new academic programs, for critical renewal of facilities, for additions to endowment, and for other capital purposes. Second, we must achieve a balance between the *rates* of growth of expenses and revenues so that the financial state of the Institute is reasonably stable. The second objective is the more difficult one, for it requires reasonably steady growth in both investment income and gift revenues, and these in turn depend critically on the state of the economy and on other variables not under our control. In the first stages of our struggle with the budget, broad and general cost control was tolerable, increases in student numbers acceptable and attainable, consolidation of selected academic activities healthy, and increases in research volume generally supportive of academic programs. But such efforts have many pitfalls too, and in order to deal with the financial situation in ways that will strengthen, and not weaken the Institute, we have undertaken a set of in-depth studies to guide future actions.

In this connection, a Committee on Research Structure, led by Professor Frank Press, was appointed to assess the impact of the changing national research climate on the operations of M.I.T. and to recommend appropriate changes in the Institute's style of conducting research. The Committee's Report identifies a series of problems, needs, and opportunities, and culminates in a wide-ranging set of recommendations which will be discussed by the faculty and administration during the coming year. The Committee concentrated on two issues: the Institute's financial situation, especially as it relates to research; and the need to develop new opportunities for young people during the 10-year period ahead when there will be relatively little faculty turnover or growth. The Report concludes that M.I.T.'s intellectual vitality and, indirectly, its educational programs can be enhanced by emphasizing research centers, closely related to departments, as a source of new research and funding opportunities. The Committee recommends that we strengthen these activities by providing a broader range of research career opportunities on the M.I.T. staff. It also identifies a series of steps which would ease the tasks of faculty members engaged in the search for research support.

The nature of the budgeting process in recent years has provided insufficient opportunity for the departments, laboratories, centers, and administrative officers to plan, more than one year at a time, for the best use of the resources that would be available to them and to discuss their opportunities and needs with us and with the Provost. To permit a more sensitive, selective, and effective budget process, we are developing the 1977-78 and the 1978-79 academic budgets simultaneously, and have begun a comprehensive review of programs in the individual Schools and academic departments as well as in some of the major centers. We are finding this process to be helpful in developing a more finely-honed sense of the intellectual opportunities available to the various departments and centers, and we expect that available resources can be applied strategically to enhance these opportunities. A parallel study of selected administrative units has begun with the hope that opportunities can be found for further economies, consolidation of efforts, and improved services.

During the past year we have had to contend with a new uncertainty of major proportions. The future financial viability of the Institute and the other graduate universities of the nation has been threatened by proposals for major changes in the overhead reimbursement policy of the Federal government. These proposals are now under intensive discussion between university business officers and the government. We hope and believe this year's round of discussions will end in a document which assures that the universities will be reimbursed for fair and reasonable costs. Nonetheless, everyone concerned with the health of the American research establishment or the well-being of the nation's distinguished universities should be aware of this danger.

Since the end of World War II the extraordinary strength and quality of American science has been fostered and primarily supported by far-sighted Federal policies which were manifestations of the belief, shared by the Congress, that an outstanding base in science and technology was a prerequisite for an adequate national defense, a healthy nation, and a prosperous economy. It was a matter of policy to encourage an increase in the volume of fundamental and applied research through the growth of the nation's existing research oriented universities and the support of new centers of excellence. This was done primarily through the mechanism of research grants



Henry Moore's recent sculpture, "Three-Piece Reclining Figure, Draped," was acquired this year and is sited in Killian Court.

to individual faculty investigators and by providing financial help with necessary facilities. At a few key institutions, M.I.T. among them, growth was facilitated further by the establishment and support of large research centers such as the Research Laboratory of Electronics, the Laboratory for Nuclear Science, and the Center for Materials Science and Engineering. Because it was recognized that the universities, especially the private ones, had no independent means of funding the additional costs of the substantial growth hoped for, a policy of full cost reimbursement was established. These arrangements, which evolved into a Bureau of the Budget document, Circular A-21, have for years been the basis of negotiations between university business officers and government contract supervisors. The consequences of favorable Federal policies are clearly evident in the preeminent position of U.S. science and technology and in the leadership of U.S. technical education.

The costs associated with research have been rising because of the combined effects of inflation and the increasing sophistication of research that inevitably occurs with the passage of time. For almost a decade Federal support of research has not kept pace with the increase in costs. However, universities have adjusted to this austere climate with only moderate impact on the quality of the research effort. At the same time a more dangerous situation has been developing. A few Federal agencies, under pressure from cost-conscious legislators, and perhaps unaware of the long-standing commitment to full cost reimbursement or the damaging effects of abandoning it, have insisted on a dramatic increase in the level of cost-sharing. Federal funding agencies, acting in response to Congressional urging, are proposing steps to limit or eliminate reimbursement for certain categories of direct research costs such as faculty time committed to research, as well as for the essential and legitimate indirect costs of research activities.

A major change in the policy of full cost reimbursement would cause extreme difficulties for the universities at almost any time. Coming now, after several years of diminished resources and extraordinary inflation, it would cause a serious disintegration of the research efforts at essentially every major university, including M.I.T. Furthermore, as the universities adjusted their allocation of resources to the new situation, all of their programs, non-technical as well as technical, would be affected. Fortunately, it has been possible to establish a re-

sponsive dialogue with representatives of the executive and the legislative branches of the government, to gain an understanding of their concerns, and to explain the complexities and limitations of university research support. We hope that these efforts will contribute to the reestablishment of constructive agreements for the Federal support of the university component of the national R & D effort.

While the Federal government's stance vis-á-vis support of research is of critical financial significance to the Institute, both in terms of the kinds of costs deemed reimbursable and the internal mechanisms which the Institute develops to take best advantage of the configuration of Federal programs (the topic of the Press Report), of equal importance is the intellectual renewal which the Institute derives from its partnerships with other organizations — among them, government agencies, private foundations, and businesses. Our desire and need for such relationships is not new. M.I.T. people have always drawn much of their stimulation from interactions extending beyond the boundaries of the Institute, but the intensity of those relationships fluctuates and they change in form over time. Organizations with quite different roles in our society share in its problems and this generates a growing mutuality of interest and a search for the ways in which their complementarity can be used to the benefit of all.

Current issues of mutual interest include the role of technology in the society, concerns about adequacy of energy and resource reserves, concerns about the environment, fiscal pressures, alarm about the effects of increasing governmental regulation, and concern for the health and viability of our democratic social system. Basically, these are all questions of adaptation to an ever changing, ever more complex technological society. They are problems involving choice among increasingly unclear options. M.I.T.'s role is to help achieve adequate understanding of the options available. Our links with governmental and industrial groups involve programs of educational renewal; continuous interaction on technical and scientific developments, and shared research interests.

M.I.T.'s continuing education efforts have emphasized two styles of endeavor — the mid-career programs of the Sloan School of Management and the School of Engineering, and the Summer Session Program's short subjects designed to highlight special topics for the benefit of experts in the field. These activities have been highly successful and will continue to be important M.I.T. efforts, but we are conscious of a growing desire for more extensive continuing education programs. This need is expressed repeatedly by alumni, governmental groups, and industrial organizations, many of which want university assistance in the development of their own advanced training programs. In responding to these needs we must consider two issues: how to be effective in this mode, and how to do it without placing undue burdens on the M.I.T. faculty. New options are being explored throughout the Institute, with special emphasis by the Sloan School and the Center for Advanced Engineering Study of the School of Engineering.

M.I.T.'s technical outreach programs and interactions take many forms, some old, some new. Well-established activities like the M.I.T. Industrial Liaison Program and the M.I.T. Associates Program are attracting an ever-increasing number of participants who, in turn, are making more effective use of the programs than was often the case in the past. Since 1974 the ILP program has grown from 95 companies to 130; the Associates Program from 30 companies to 40. This growth is a reflection of M.I.T.'s growing work on industrially-related technology, and industrial recognition of the importance of the broadest possible basic and applied research base to support corporate developments. Very few companies can afford a corporate research program as extensive as that available at M.I.T. but even those which can, use M.I.T. as a foil for testing the validity of their efforts.

In a complementary direction, many new M.I.T. activities such as those in the Energy Laboratory and the Polymer Processing Program are focused on industrial processes and therefore need continuing industrial guidance and association. In the Energy Laboratory, an Advisory Board functions well in its intended role, reviewing laboratory activities and serving as a communication link to interested individuals in industrial organizations. In addition, scientists and engineers from several companies have participated in the activities of the Laboratory as visitors and a number of companies have provided financial support. We are encouraging this style of relationship despite some criticism of undue industrial influence on the Laboratory for we believe that the advantages far outweigh the risks. Everyone involved has been most careful to avoid inappropriate use of this unique set of relationships. Industrial involvement in the Polymer Processing Program is much more formal and intense than in the Energy Laboratory. Participants join the Program, help finance it, and share in its guidance, involve their own staff members in the work as a regular practice, and seek to apply the results.

In addition to such participation on a laboratory or programmatic basis, a growing number of firms is finding specific research activities of individual faculty members or faculty groups of sufficient interest to share in their support. Though such industrial support has always been present, today's congruence of industrial and Institute interests make such help more attractive, from the perspective of both the faculty member and the potential sponsor.

The Institute is highly interdependent, both intellectually and financially, with the world it serves. Actions taken to strengthen the Institute have ripple effects in other organizations; changes in policy on the part of others generate both new opportunities and new constraints for the Institute. Our intellectual and financial policies need to take cognizance of these interdependencies. We are, in effect, trying to solve a set of simultaneous equations — to bring the Institute into financial equilibrium, to enable its departments to renew themselves at a pace characteristic of the traditions which have made them foremost in their fields, to develop in many parts of the Institute the capacity to focus explicitly on the nature of modern technological society, and to increase the areas of partnership with other organizations, especially industry. Our efforts are iterative and interactive, involving many kinds of activities, many kinds of colleagueship; events in one arena will change the constraints and opportunities both for itself and for others.

What follows in these pages is a sampled view of the array of activities under way. We hope that their relationships to each other and to our main themes will be apparent.

This year we would like to take note of the 25th anniversaries of three important components of modern-day M.I.T. — the Lincoln Laboratory, the Sloan School of Management, and the School of Humanities and Social Science. Each has received considerable recognition in its own sphere. Although very different, each has made substantial and unique contributions to the intellectual and educational life of the Institute, as well as to the definition of the kind of science and engineering which the Institute has come to represent to the world at large.

During the 25 years in which these organizations were growing, the Schools of Science, Engineering, and Architecture and Planning also were evolving. Prior to World War II, Karl Compton and Vannevar Bush were leaders in a great strengthening in the engineering disciplines at M.I.T. particularly in regard to the quality and breadth of studies on which they were based. During the past 30 years engineering activities at M.I.T. have been transformed into a group of rapidly evolving, intellectually mobile disciplines with deep roots in science. Under Karl Compton in the 1930s the sciences had been transformed from programs whose primary role was providing service courses for engineering students to important disciplines in their own right which, forged in the crucible of World War II, took their place as eminent disciplines at M.I.T. The School of Architecture and Planning, descendant of the architecture program which was an original part of the Institute and of the nation's second city planning program founded in 1932, entered its modern period in the early 1940s, and today is one of the strongest and most consistent advocates of a more human environment for all citizens. The Institute of today is made up of all of these, working in partnership. In this Report we would like to highlight the contributions of those Institute units which have just reached the quarter-century mark.

LINCOLN LABORATORY

The Laboratory was established in 1951 following a request to President James R. Killian, Jr. from General Hoyt Vandenberg, then Air Force Chief of Staff. Shortly before, the Soviet Union had detonated a thermonuclear device — years before such an event had been anticipated in the United States — and long-range, high-speed aircraft were already an operational reality. The country could no longer rest its security on geographic isolation, and it had no air defense of any consequence. It was clear that a large and intensive effort would have to be mounted if the technology of aircraft control and warning were to catch up to the rapid developments that had occurred in aeronautics and weaponry. This was what M.I.T. was being asked to do, and there was good precedent for the Institute to respond favorably.

Eleven years earlier a similar appeal from the Microwave Committee of the National Defense Research Council had led to the formation at M.I.T. of the Radiation Laboratory, which was to become the largest wartime university laboratory devoted to technical military problems, the center for American radar development. The Radiation Laboratory required new concepts of management as well as new ways of accomplishing scientific technological developments under great pressure, and this managerial and technical understanding still resided at M.I.T. in the many alumni of the Laboratory who had remained on or returned to the faculty in 1946, particularly in the Research Laboratory of Electronics, the direct descendant of the Radiation Laboratory. Some of these people, Jay W. Forrester, Albert G. Hill, M. M. Hubbard, Louis D. Smullin, George E. Valley, Jr., Jerome B. Wiesner, and Jerrold R. Zacharias, had been among the several groups of scientists who took part in a series of examinations of our air defense capabilities following the Russian atomic test, and had contributed to the early definition of needs and technological possibilities. It was to these and their associates that the Secretary of the Air Force referred in a letter to President Killian in 1952 when he noted how fortunate it was for the Air Force and the country that so many eminent scientists who had made notable contributions during the war were in a position to contribute more.

Lincoln is thus, both technologically and managerially, the direct descendant of the Radiation Laboratory of World War II. There is, however, an important difference. Where the Radiation Laboratory was concerned with the development and exploitation of a new technology — radar — Lincoln was established to attack an urgent national problem. This called for a new level of technical conceptualization, the aggregation into a single integrated system of a number of components — aircraft, radars, computers, telephone networks, and teams of human operators — each of which, in its own right, represented a system of major technical and organizational complexity.

Success required teamwork among large numbers of individuals with diverse talents, professional backgrounds, and experience. It required the support and cooperation of an important segment of American industry and, perhaps most critically, it required sponsorship that would assure the Laboratory freedom to focus on and follow the problem, to accept the risks inherent in new and developing technologies, and to reject solutions dictated by simple expedience or political consideration.

In any event, it was a successful approach, and by 1958 the first sector of the Semi-Automatic Ground Environment for Air Defense (SAGE) was in operation and the Distant Early Warning Line — a chain of radar and communications stations stretching from the northwest coast of Alaska to the eastern shore of Baffin Island — had been installed. The continuing tasks of new weapons integration and the inevitable upgrading and improvement of the original system had been transferred to industry and to the MITRE Corporation, an independent, non-profit organization, newly formed around a nucleus of Lincoln staff.

If the air defense problem had been solved, other problems remained, and the Secretary of the Air Force wrote to President Julius A. Stratton that he regarded the Lincoln Labo-

ratory as a technical resource of great value for the future; he proposed to support at Lincoln on a long-term, stable basis "a program of research in air defense electronics and related fields, and in the early development of advanced systems which may emerge from such research. The program would be oriented in content to correspond with M.I.T.'s areas of competence and its responsibilities as an educational institution and would be of substantial size, commensurate with the talent and facilities available."

In succeeding years, the major involvement of the Laboratory has been with the problems of defense against ballistic missiles and the achievement of reliable, world-wide communications. More recently, these broad areas of concern have been expanded to include problems of space and tactical surveillance and civil air traffic control, the latter supported by the Federal Aviation Administration.

None of these programs has led to the massive system implementation effort that was associated with SAGE. In part, this stems from the national decision to maintain a high level of defense research but not to deploy a ballistic missile defense system; in part, it can be attributed to M.I.T.'s view of the role of a university research center in which the governing force is creative thought, and where even the most cherished research projects must, in the later stages of development, be handed over to others. In the early 1950s, when a major revolution in electronic technology was in full swing, there had been few organizations with the capability to take on the production, development, and installation of a system as complex as SAGE. That is no longer true, and the transfer to industry of scientific conceptions and new technology properly occurs much earlier in the research and development cycle.

However, the accomplishments in Lincoln Laboratory, and the rationale for support of a large university research center such as Lincoln, extend beyond the development of specific systems or the solution of specific problems. In addition, such a Laboratory functions as a clinic in which the ideas or discoveries of the larger Institute community can be tested, nurtured, or tempered through exposure to the demanding pragmatism of complex real-world problems. Thus, Lincoln has played an essential role in giving technological substance to those concepts of information and control which were exciting the imagination of many of us 25 years ago and were being prophetically espoused by Norbert Wiener as the advent of the Second Industrial Revolution.

The core memory, invented and put into use at Lincoln, and the high-speed switching transistor, engineered into computers at Lincoln, made the high-speed digital computer a reliable, economic and ubiquitous device. Digital data transmission techniques have made it possible to "knit" together large data processors and to deliver information efficiently to even the smallest user. Integrated digital circuitry which the Laboratory has developed or sponsored has already brought sophisticated computation and control systems into our homes and daily lives. Equally important has been the variety of applications of these devices and techniques and thereby the stimulation of new invention and new fields of investigation. The use of computers for real-time control of operations is now widely accepted, continually expanding the field of engineering. It was a radical concept, generally regarded as impractical until it had been demonstrated on a large scale in a number of areas at Lincoln. Computer graphics and computer aided design, large-scale simulation and computer assisted instruction all have roots in the Laboratory.

There is an integrated impact of these efforts that is not conveyed by the listing of specific accomplishments. It represents the achievement of a technological "critical mass" that is derived in part from the size of the effort, in part from investigative freedom, and in part from a happy symbiosis — not always devoid of internal strains — between a large organization of problem solvers and builders, and the individualized imagination and creativity that characterize our faculty and students.

If we look towards the future, we can perhaps see represented in the Lincoln/M.I.T. combination an evolving organizational and intellectual competence to deal with complexity and particularly with the expanding problems and opportunities afforded by modern technology. We will certainly need such competence if we are to meet the formidable and already forseeable challenges of world-wide energy management, environmental control, and social ecology.

ALFRED P. SLOAN SCHOOL OF MANAGEMENT

The problem of managing modern industrial society involves many tasks we do not yet know how to do or even to think about in an orderly way. We need to encourage innovation and change without permitting society to bear undue risks from new technologies and institutional arrangements. We need to develop fairer societies where the benefits of increased productivity and capital accumulation are widely shared without reducing the motivation of those who are principally responsible for economic development. We need to discover a basis for evaluating the legitimate claims of future generations to resources which might otherwise be irreversibly consumed in the near term. We need to find ways in which complex technical and scientific choices can benefit from broader understanding of those whose lives will be affected. We need new knowledge to understand each of these issues and more new knowledge to understand the trade-offs among them.

The Sloan School was organized at M.I.T. in 1952 because it was recognized that a deep understanding of new technologies would be a necessary ingredient in management systems of the future; that rigorous and analytic methods could be applied in seeking to understand the economic tides, technological developments, and human complexities of contemporary enterprises, public and private. The M.I.T. strategy of students and faculty working together to learn through research and classroom interaction seemed an ideal way to attack these difficult problems.

With the founding of the Sloan School, M.I.T. continued the process of innovation in management education which had begun at the Institute almost 40 years earlier. In 1914, M.I.T. was one of the first major universities to offer management education to undergraduates. Course XV has, over the years,

produced some of M.I.T.'s most distinguished alumni, including James R. Killian, Jr. It continues to attract some of M.I.T.'s most able undergraduates. A second major innovation in management education at M.I.T. also preceded the formation of the Sloan School. The Sloan Fellows Program, first offered in 1931, was designed for men and, more recently, women with 10 to 15 years of successful professional experience who were about to undertake more general management responsibilities. This program continues to be unique in the world. It attracts outstanding individuals, from both inside and outside the U.S. and from the public and private sectors, to a 12-month program leading to an S.M. in Management. It has been referred to as the flagship in the recently-proliferating fleet of continuing management education programs.

In 1952, when M.I.T. organized the Sloan School, the process of innovation continued. Prior to that time education of young men and women at the master's level was dominated by so-called M.B.A. programs — and these programs were dominated by a commitment to a particular pedagogical device — the case method. While effective for some purposes, programs based on a commitment to this method seemed to have some disadvantages which the Sloan School set out to overcome. The Sloan School looked forward to a world of change — a world in which new ideas, new technologies, and new forms of organization would have a substantial impact. It, therefore, placed greater emphasis on preparing students for the future than on exposing them to past practice. The Sloan School's new approach to management education required a different faculty and a different student body than were to be found at that time in other schools of business and management. During the years since its founding, the Sloan School approach of balancing new approaches to new problems with an understanding of on-going institutional arrangements and procedures has evolved into programs which today combine an array of educational methods. Further program innovations at Sloan included the beginning of a program for Senior Executives in 1956, a Doctoral program in 1961, and an Accelerated Master's program in 1971. The Sloan School's departure from prior educational practice has had a substantial effect on the design of programs in other management schools. Shortly after its beginning the School moved into the leading rank of business and management schools in the country.

The School's faculty also made a series of intellectual contributions which confirmed the hope that the Sloan School could contribute important new ideas to the practice of management. Professor Douglas MacGregor's work on Theory X and Theory Y as self-confirming management styles has substantially influenced organization theory and practice since it was first announced at a Sloan School convocation in 1956. Professor Jay Forrester's early work on Industrial Dynamics has led to the development of a methodology which he and others have applied to some of the most challenging problems in modern society. While this work has produced some controversy, there is no doubt it has constructively stimulated fruitful debate and focused attention on issues of great importance. In the field of finance and capital markets, Sloan School contributions have been central to our new understanding of how such markets work — how investors, including the Institute, can take advantage of this new understanding, and how regulatory agencies can more effectively serve the public interest. In the field of mathematical modeling and the application of computer technology to important management problems, the Sloan School was an early leader and remains strong to this day. A Center for Information Systems Research recently has been formed in the School to facilitate stronger interaction with industry in this area. Close collaboration of Sloan faculty with those from the Department of Economics and other parts of the Institute through the Energy Laboratory has led to major contributions to our understanding of the issues underlying United States energy policy, and have substantially contributed to the evolution of that policy.

Recognizing health as one of the nation's largest service industries and certainly one with a great need for more effective organization and management, Sloan faculty began 10 years ago to carry out research in this domain. It was during this period that the joint Harvard–M.I.T. Program in Health Sciences and Technology was developing, and its presence provided a resonance for Sloan School interests. Out of this research have now grown materials which can serve as the basis for the teaching of health professionals with respect to management. One major Sloan program in this area is conducted in collaboration with the American Association of Medical Colleges. In this program more than 120 deans of medical schools have come to M.I.T. for a short, specially designed

management course. This is then followed by a slightly longer experience designed to extend beyond the dean to his school's administrative structure. A third level program in the medical school itself leads to the development of plans and strategies which are already beginning to have an impact on curricula, costs, controls, and the organization of important medical centers.

Management is increasingly the management of change. The world needs to find new ways to manage modern industrial society and needs men and women with the energy, imagination, and will to undertake these tasks. These people increasingly need knowledge and the means to understand the world they find. The Sloan School is committed to continued innovation both in the programs it offers and in the research projects it undertakes. The School is currently considering educational options which suggest that the next 25 years will be as exciting and productive as the first have been.

SCHOOL OF HUMANITIES AND SOCIAL SCIENCE

In 1949 the Committee on Educational Survey chaired by Warren K. Lewis, Professor of Chemical Engineering, recommended the establishment of a School of Humanities and Social Science at M.I.T. The Committee noted that English, history, modern languages, and a scattering of general studies had always been a part of the Institute's curriculum and that economics had been taught since President Francis Amasa Walker's day. These subjects had been offered primarily to broaden the education of scientists and engineers. Formalization as a new School, the Committee agreed, would focus attention on the mastery of problems arising from the impact of science and technology upon society. The School was established in 1950 with John Burchard as its Dean.

Many of the changes that have taken place in the Institute since then reflect new conditions in the world around us. The insights of the Lewis Committee have proven to be basic touchstones for the Institute throughout this 25-year period, and their observations are as appropriate today as when they were written.

We are awake now, at last, to the knowledge that our rich and prosperous nation cannot withdraw into isolation. We have discovered that the social institutions of the United States are subject to forces similar to those that are molding the destinies of Europe and Asia. The very concepts of democracy, of equality and opportunity, and of leadership are shifting and developing in the American mind. The utter waste of two world wars confronts us with the necessity of considering the finite limits of our national resources. Even more significant, and perhaps more threatening to our present form of democracy, is a persistent tendency to growth and centralization of control in all organizations and institutions, industrial, financial, educational, and labor. There is a concerted effort to increase the efficiency of management and to eliminate fluctuations in economic and social status. One must at times wonder whether the price of some of these changes may be an ever-diminishing premium placed on the man who is different, on the function and qualities of imaginative and creative leadership.

Democracy as we have known it for more than two hundred years is the fruit of leadership that rises from the initiative and individuality of the people. If this nation is to hold to a high goal, it must continue to cultivate a superiority of spirit and intellect.

Thus wrote the Lewis Committee in 1949. The Committee went on to say:

There can be no dispute about the increasing importance of the humanities and the social sciences in the education of scientists, engineers, and architects. It is M.I.T.'s duty to prepare its students for social responsibility and for a rich and complete life. But, important though these objectives may be, technological and social problems are now so inextricably interwoven that the humanities and social sciences are also essential components of man's professional education. Without an adequate cultural background, a technical specialist is no longer qualified for leadership in his own field.

The report then lamented the fact that the contribution of the humanities and social sciences to M.I.T.'s undergraduate education had never been entirely satisfactory, due in part to a lack of status for the staff commensurate with that in other departments and to the necessity to provide "service subjects" concerned primarily with instruction at an elementary level. The Committee continued:

Now, however, there is a growing concern with human and social problems, an increased awareness of the interplay between science and technology on the one hand and the conduct of human affairs on the other, and an awakened realization of the fruitfulness of the techniques of the natural sciences in the study of human and social problems. **We believe that these trends now make possible the development of the humanities and social sciences at advanced professional levels in the en-**

vironment of a technical institution. The concepts and techniques of science and engineering can give important insight into certain kinds of human, social, philosophical, and historical problems and the atmosphere of an institution like M.I.T. can be made attractive to men interested in these phases of the humanities.

During the 25 years since its founding the School has had a brilliant history. Most of its departments and sections have assumed positions of leadership on the national and international scene. Some, including economics, linguistics, political science, and psychology have become dominant influences in their fields. These achievements occurred in those areas of the social sciences where faculty members were motivated primarily by professional interests; where the department's intellectual direction derived from the challenges of the discipline itself. In those areas of study, primarily in the humanities, where the perceived needs and interests of undergraduates provided the impetus, development has been less consistent and has been harder to evaluate. Changing student interests have made it difficult to develop sustained academic programs of high quality. Fortunately, once again there appears to be serious interest in humanistic studies on the part of our undergraduates, especially with regard to the intersection of social and scientific or technical issues, and also, interestingly, in the creative and performing arts.

The "Lewis Committee" correctly anticipated the need for effective and supportive educational and research programs in the social sciences and the humanities. Those programs have provided the Institute with a reservoir of talented people who readily turned their ideas and skills to bear on the initial framing and subsequent investigation of issues which might otherwise have had a purely technical form — energy, environment, regulation, etc. At the same time, groups within the School of Humanities and Social Science have been examining how they could make a more effective contribution to M.I.T.'s educational program. The new Institute Requirement in the Humanities, Arts, and Social Sciences, which had its first full operational year in 1975-76 after a year of transition, represents one such development.

Another contribution to the general education of M.I.T. students has been the Writing Program for undergraduates, offered since 1974. The Program appeals to many students, ranging from those who feel a need to improve their communication skills to a significant number of students who have a deep and continuing interest in writing. As the Program grew and adopted a variety of innovative methods, it became the subject of widespread debate about such matters as the allocation of resources, the qualifications of certain members of the instructional staff, and the appropriateness of academic credit for some of the work. To help understand and resolve the many issues raised, in April 1975, Dean Hanham appointed a small study group composed of M.I.T. faculty members and outside specialists who, after a year of study and discussion, have strongly endorsed both the intent and performance of the Program and proposed a number of significant steps to stabilize and improve it. This report will be considered during the coming year with the expectation that the future characteristics and scope of the Writing Program will be decided promptly.

Other developments in the School include the merger of Philosophy and Linguistics, to be discussed later in this Report, and increased attention to the interplay between technology and society through the study of selected societal problems. For the past three years a study group chaired by Professor Elting Morison has been considering how the humanistic and technological streams of the Institute might be brought together to understand vital issues of a technological society. Existing resources, i.e., existing unfilled chairs and current faculty members interested in the program, have been sufficient to start a small core of research and educational activities. Research will center on the examination of a small number of carefully selected sociotechnical problems in all their complexity, and educational activities are based around problem-oriented, collaborative efforts of faculty and students. The educational program, though currently small, builds on a decade of experimenting with and reflecting upon undergraduate education, including UROP, the Concourse Program, the Unified Science Study Program, self-paced teaching methods, and the two special undergraduate degree programs combining Humanities and Engineering or Science.

For years the M.I.T. faculty — humanists, engineers, and scientists alike — have been searching for the role of the humanities at the Institute. Within the M.I.T. community the sense that solutions for many of society's dilemmas depend upon more satisfying fusions of our different kinds of knowledge has been expressed in many different ways and places. Some faculty members have moved beyond the boundaries of their own fields to work with others on problems, such as the future supply of energy, whose solutions appear to depend on the intersection of a variety of factors — political, economic, technological, and scientific. Others are seeking to discover more about the impact of science and engineering on cultures developed at other times and places. Still others have started informal seminars for the study of such concepts as meritocracy, equality, and justice in a technological society. Activities of this sort suggest the extent to which the mood of the community is moving beyond strictly professional interests. But they also suggest, in their number and variety, a dispersion of energy. As one faculty member said recently, "There is no adequate focus in the Institute for what everybody talks about all the time." We hope that from the inter-School collaborations developing around research and teaching on problems of technology and society such a focus might grow.

* * * * *

To close this anniversary section, we note that the Institute has a different intellectual character than it would have had without the Lincoln Laboratory, the Sloan School of Management, and the School of Humanities and Social Science. M.I.T. is distinguished for its achievements in science and engineering, and its primary focus has always been, and always should be, in these areas. The nature of our educational pro-

M.I.T. Symphony Orchestra Conductor David Epstein motions for bows for viola soloist Marcus Thompson and orchestra members at their April 19 concert in Washington's Kennedy Center for the Performing Arts.

grams and the kinds of research possible have been significantly enhanced by the presence and the excellence of those parts of the Institute whose anniversaries we celebrate.

While our emphasis in recent years has, of necessity, been on ensuring the health and vitality of those established activities of the Institute which are its main force and which have always given it its unique character and style, that health and vitality also entails the development of new activities which capture the imagination of students and faculty, and which provide stimulation and new perspectives for ongoing programs. In these financially tight times new activities cannot be undertaken lightly — they involve commitments of energy, space, and money which are all too scarce. On the other hand, if they contain the seeds of intellectual renewal they are an important investment for the Institute to make in its future.

We have discerned among young people interested in studying at M.I.T. a growing interest in professional careers for which the Ph.D. with its emphasis on research is not a prerequisite. In response we have been developing several programs in which the Master's Degree represents a coherent course of study in and of itself and not primarily a way-station on the path to a Ph.D. We have found considerable interest among the faculty in working with students in such programs; their development has enabled us to respond to a new range of interests without expanding the size of the faculty.

The School of Science has extended Course XXV and now offers an Interdisciplinary Science Master's Program. The objective of this program is to prepare students for positions in industry, government, education, and medicine which often require interdisciplinary breadth as well as a strong background in science. Specified programs were offered this year in Animal Cell Science, Science Education, and Environmental Chemistry; 12 students were enrolled in the first term and 16 in the second. It is anticipated that other interdisciplinary science areas will be developed in the next few years.

The School of Engineering began a Master's Degree Program in Technology and Policy. This program, a cooperative venture between departments in the School and members of the faculty in the social sciences, represents a tangible effort to create integrated educational activities in the social sciences and engineering. The program is particularly appropriate for students who wish to study economics, social science, systems analysis, and policy making at the same time they are concentrating in one of the engineering disciplines.

In the Sloan School of Management, as part of a larger set of activities in the field of health management, a new Health Management Executive Development Program was inaugurated this year. This 12-month program leading to the degree of Master of Science in Management is aimed at mid-career health care practitioners, educators, researchers, and administrators. Six health professionals were admitted to this program in June 1975; three medical school deans; two senior directors of nursing services; and an executive from the Department of Health, Education and Welfare.

An additional new academic arrangement of considerable promise occurred in the School of Humanities and Social Science. As of July 1, 1976 the Linguistics and Philosophy programs have been combined in a renamed Department of Linguistics and Philosophy (Course XXIV). At the same time a new undergraduate degree program in Linguistics, Philosophy and Psychology, with the title Language and Mind, was agreed to as an option in Course XXIV. The changed administrative arrangements for Linguistics and Philosophy offer considerable advantages in terms of intellectual coherence and also

provide a new base for moving into the more theoretical aspects of the Cognitive Sciences. Together with the Department of Psychology, work has begun to develop a new Ph.D. option in Cognitive Studies, and we look forward to the possibility of a new laboratory or center in this field that is both experimentally and theoretically oriented. Such a laboratory would form a common base for development not only in Psychology, and Linguistics and Philosophy, but also for building on work in the communications area already under way in the Research Laboratory of Electronics, in the Artificial Intelligence Laboratory, and in various computer science groups.

A new physical development on the campus which has considerable educational potential is the installation of a cable television system under a grant to the Center for Advanced Engineering Study from the Alfred P. Sloan Foundation. The cable forms a spine down the center of the campus which, with a few branches, reaches to almost every center of activity on campus. The system was tried out during Independent Activities Period, when news, public service announcements, videotaped courses and cultural events were transmitted. Materials were prepared by student groups, faculty, visitors to the Institute, and by the staff of the CAES. As anticipated last spring, there are currently more than 1,000 receiving stations in the dormitories plus about 50 stations in classrooms, departmental lounges, offices and corridors.

In April 1976, the Sloan Foundation awarded M.I.T. a further grant to continue programming experiments on the cable system. A Cable Television Policy Board, chaired by Professor Roy Kaplow, will monitor our experience with the cable and help develop guidelines regarding transmission access, suitability of program material, etc. As we experiment with the instructional and cultural uses of such a system we look forward to the time when it is fully integrated into the life of the Institute.

Activities in the arts at M.I.T. continue to be vigorous and stimulating to the community as a whole. Several major sculptures were acquired, largely through the generosity and vision of good friends and, in several cases, of the artists themselves. These sculptures include "Transparent Horizon" by Louise Nevelson, sited adjacent to the new Ralph Landau Building, and "Three-Piece Reclining Figure, Draped" a recent bronze by Henry Moore which is sited to the side of the Killian Court. In other arts-related activities, the M.I.T. Symphony Orchestra performed at the John F. Kennedy Center for the Performing Arts in Washington, D.C., under the sponsorship of the Council for the Arts and the M.I.T. Club of Washington. The concert was given in conjunction with a Club-sponsored Symposium on Technical Innovation. Both the symposium and the concert were a considerable success. As Paul Hume noted in *The Washington Post:*

The M.I.T. Symphony Orchestra came to town last night and its students of architecture, biology, computer science, earth and planetary science, physics, psychology, and urban planning had no difficulty in sounding like a first-class university orchestra . . . the players . . . offered their Kennedy Center audience a program that would greatly honor the lists of any of our major orchestras. It was of a kind that the majors all too rarely put together . . . The might of M.I.T. is clearly well divided between the sciences and the fine arts.

Paul Hume made an understandable error, for which we forgive him since he came so close to the truth. The might of M.I.T., by which we take him to mean its vigor and excellence, is not **divided** between the sciences and the fine arts. Rather, as in the case of the young people who performed that night, the talents of science, engineering, art, and concerns for human and social issues are **combined** at M.I.T. The resulting sense of hard work, creativity, and the excitement of achievement or discovery pervades the Institute and is part of what makes M.I.T. an exciting place to study or work. This phenomenon is demonstrated by increasing numbers of undergraduate and graduate applications, and the increasing academic talent of those who are admitted. It is demonstrated by the efforts of people in all parts of the Institute to improve the living and working conditions of those who study and work here, with particular attention to the stresses and strains experienced by those who are statistical minorities in this predominantly white, male community, but who are contributing much to its excellence. It is also demonstrated by the increasing attraction M.I.T. holds for the people of other nations.

We have noticed in recent years an increase in the kind and the number of Institute activities involving other nations. These include an increase in the number of foreign students, both graduate and undergraduate, who now comprise almost one-fifth of the student population. We are increasingly asked, not only to admit more foreign students from a greater number of countries, but to admit them under new and contractually-based arrangements. Foreign consulting and research opportunities always have been available to our faculty, but as other nations analyze their economic and technological needs, we see an increased incidence of such activities and proposals for new kinds of institutional arrangements. We are aware of the increasing numbers of foreign alumni, many of whom are in positions of considerable responsibility in their countries and are asking us for professional support. Each of these trends raises policy issues for the Institute, some of which come upon us unexpectedly and in ways which create considerable stress and publicity. Taken together these trends raise even larger policy issues regarding our responsibilities as an institution of international reputation and the ways in which we are organized to meet those responsibilities. We have mechanisms for deliberating the implications of some of these developments, one of which is the newly formed Committee on International Institutional Commitments composed of faculty, students, and administrators. However, the magnitude and scope of the issues arising from our international reputation deserve careful thought and discussion in all parts of the Institute.

That so many people and nations seek to share in the life of the Institute is no surprise. It is an exciting and varied place, continually inventing new possibilities for the future. The issues and activities we have described in this Report are those of a healthy, creative university with a clear vision and purpose. As we close this essay we would like to recall the concluding remarks of the late Jacob Bronowski in his television series "The Ascent of Man." We think these words are particularly appropriate for the Institute and its extended family of alumni and friends:

. . . every man, every civilization, has gone forward because of its engagement with what it has set itself to do. The personal commitment of a man to his skill, the intellectual commitment and the emotional commitment working together as one, has made the Ascent of Man.

IN SPECIAL RECOGNITION

The individual efforts and distinctions on the part of the faculty at M.I.T. have been many during the past year. Two members of the faculty were elected to the National Academy of Sciences; eight members were elected to the National Academy of Engineering; and three were elected to membership in the American Academy of Arts and Sciences. David Baltimore, American Cancer Society Professor in the Department of Biology, was honored as co-recipient of the Nobel Prize in Medicine and Physiology. Professor Baltimore, age 38, and two others were cited "for their discoveries concerning the interaction between tumor viruses and the genetic material of the cell." Manson Benedict, Institute Professor Emeritus, was honored by the award of the National Medal of Science.

Of special note during the year were the appointments of two members of the faculty to the distinguished rank of Institute Professor: Dr. Noam A. Chomsky, Ferrari P. Ward Professor in the Department of Foreign Literatures and Linguistics; and Dr. Nevin S. Scrimshaw, Head of the Department of Nutrition and Food Science. Dr. Frank Press, Head of the Department of Earth and Planetary Sciences, was honored as the fourth recipient of the James R. Killian Faculty Achievement Award.

The past year saw several appointments to senior posts that should receive special mention. Professor John M. Deutch was appointed Head of the Department of Chemistry; Professor Stephen Erdely, Director of Music; Professor Morris Halle, Acting Head of the new Department of Linguistics and Philosophy; Dean A. Horn, Director of the Sea Grant Program; and Professor Peter A. Wolff, Director of the Research Laboratory of Electronics. Dr. John Ross, Professor of Chemistry, and Dr. Suzanne Berger, Professor of Political Science, began their terms as Chairman of the Faculty and Associate Chairman, respectively.

The past year also marked the retirement of nine distinguished members of the faculty. Their years of service to the Institute and to their students will long be remembered and appreciated. They are: Professor William H. Brown, Department of Architecture; Professor Mason Haire, Sloan School of Management; Professor Harold R. Isaacs, Department of Political Science; Professor Charles P. Kindleberger, Department of Economics; Professor Richard C. Lord, Department of Chemistry; Professor William T. Martin, Department of Mathematics and the Division for Study and Research in Education; Professor Brandon G. Rightmire, Department of Mechanical Engineering; Professor Carroll L. Wilson, Sloan School of Management; and Professor Walter Wrigley, Department of Aeronautics and Astronautics.

Accepting the Nobel Prize in Medicine and Physiology from King Carl XVI Gustaf of Sweden, Professor David Baltimore was cited for his "discoveries concerning the interaction between tumor viruses and the genetic material of the cell."

Of particular sadness to us during the year were the untimely deaths of several respected colleagues and advisors.

Douglas P. Adams, Professor of Mechanical Engineering, died in October 1975. During his 35 years at M.I.T. he developed a way of handling nomograms via digital computer and became widely known for his research in kinematics, stereo-electronic recording of surfaces for criminological purposes, computer models of buildings for piping and circuitry, and computer regulation of urban traffic flow.

Alexander J. Bone, Associate Professor of Transportation Emeritus in the Department of Civil Engineering, died in March 1976. Known by generations of students as "Mr. Transportation," he was instrumental in the planning of the Massachusetts Turnpike, the Garden State Parkway, the John F. Fitzgerald Expressway, and Route 128 which surrounds Boston.

John E. Burchard, Dean Emeritus of the School of Humanities and Social Science, died after a long illness in December 1975. Close friend and trusted advisor of five M.I.T. presidents, as the first dean of the School of Humanities and Social Science, he developed a vision of what the arts and humanities could be at M.I.T. — a vision which was an important force in establishing within the Institute the traditions of a modern university. Equally at home in the worlds of science and of the humanities, and widely respected architectural critic and historian, he helped shape in countless ways the present style and character of the Institute.

Marshall B. Dalton, one of M.I.T.'s most active and respected alumni leaders who, with 39 years as a member of the Corporation, was its senior member, died in March 1976. His participation in Institute affairs spanned 60 years — including major roles in every major capital funds drive conducted by the Institute, membership on five different Visiting Committees, Trustee of the M.I.T. Pension Association and advocate of strong retirement plans for staff and employees, and long-time

leader in fraternity affairs. Beloved by students, faculty, staff and employees, he is much missed.

Frederick G. Keyes, Professor Emeritus of Physical Chemistry and Head of the Department of Chemistry from 1923 to 1945, died in April 1976. His formal association with the Institute spanned the years 1910 to 1950, but he continued in active association with the Department of Chemistry for many more years. An internationally known physical chemist and leader in cryogenic research, he was also co-developer of the Keenan-Keyes steam tables used throughout the world as the basis of modern steam generating plant design.

Malcolm G. Kispert, M.I.T. Institute Secretary and former Vice President for Academic Administration, died unexpectedly in September 1975. For more than 25 years he carried a succession of important administrative responsibilities with great competence and skill. His warm friendship, great good humor, and capacity for human understanding and compassion are greatly missed.

Norman Levinson, Institute Professor and Professor of Mathematics at M.I.T. for 38 years, died in October 1975, after a long illness. A scholar widely recognized for his research on differential equations, analytic number theory, and other branches of analysis, he was a mathematician of the first magnitude. His dedication to excellence has been an indelible influence on the intellectual life of the Institute.

Alfred L. Loomis, member of the M.I.T. Corporation for 44 years and important contributor to the development of M.I.T.'s research and educational programs, died in August 1975. Mr. Loomis, who achieved success as a physicist, financier and lawyer, worked to strengthen United States science in the period between World Wars I and II. He worked closely with President Karl Taylor Compton when M.I.T. began its rise to prominence in graduate studies, science, and basic research; aided in the establishment of the Graduate School in 1952; and served as Chairman of several Visiting Committees, including biology, physics, and mathematics.

Henry L. Seaver, member of the M.I.T. faculty for 46 years, died in November 1975 at the age of 97. Joining M.I.T.'s Department of English and History in 1901, he subsequently served as Professor of English and History and as a member of the Department of Architecture. A collector of fine books and autographs, including those of King Henry VIII and Queen Elizabeth I, which he used in his teaching, he contributed much to generations of M.I.T. students.

Albert O. Seeler, Professor of Medicine and Head of the M.I.T. Medical Department, died unexpectedly in February 1976. Dr. Seeler was responsible for the improvement of health care services during a period of unprecedented growth in the use of the Medical Department, and led in the development of a wide range of innovations including exemplary programs of student and employee health care, the environmental medical service, medical supervision of academic and research programs, and the M.I.T. Health Plan — a comprehensive health care service for faculty, staff, and employees.

Thomas K. Sherwood, Dean Emeritus of the School of Engineering, died in January 1976. A distinguished chemical engineer who was an authority on mass transfer under turbulent flow conditions, he was a founding member of the National Academy of Engineering, and in 1966 was given special recognition as one of M.I.T.'s most eminent faculty members with his appointment as the first Lammot DuPont Professor of Chemical Engineering.

Victor P. Starr, Professor Emeritus of Meteorology, died in March 1976. A recognized authority on the circulation of planetary atmospheres, he developed the theory of negative viscosity. He was a superb guide to younger scholars and, during his 27 years on the faculty, supervised about one-quarter of all the doctoral theses in the department.

Uncas A. Whitaker, Life Member Emeritus of the M.I.T. Corporation and founder and Chairman of the Board of AMP, Incorporated, an international leader in the design and manufacture of electrical components, died in September 1975. During the 14 years he served as a member of the Corporation he was a guiding force in the development of the life sciences, biomedical engineering, and advanced training in medicine. His vision also has taken tangible form in the Uncas A. and Helen F. Whitaker Building for the Life Sciences (Building 56), support for the joint Harvard–M.I.T. Program in Health Sciences and Technology, and the establishment of the Whitaker Professorship of Biomedical Engineering. He was totally devoted to the Institute and his vision of the linkages between science and engineering on one hand, and medicine on the other was a matter of deep conviction to him which we shall seek to realize.

Minor White, a premier American photographer and Professor Emeritus of Photography, died in June 1976. He was responsible for the establishment of the Creative Photography Laboratory at M.I.T. as well as a number of major photography exhibits. His artistic influence depended not only on his work as a photographer, but on his service as teacher, critic, and publisher. His photographs have been exhibited in museums and galleries throughout the country and many are included in the permanent collections of major museums.

These men have been outstanding examples of the strength and variety of M.I.T.; they will be remembered and honored by generations of their students, friends, and associates.

Jerome B. Wiesner, President
Paul E. Gray, Chancellor

October 1, 1976

STATISTICS FOR THE YEAR

The following paragraphs report briefly on the various aspects of the Institute's activities and operations during 1975-76.

REGISTRATION

In 1975-76 student enrollment was 8,482, an increase of 432 over the 8,050 enrolled in 1974-75. This total was comprised of 4,433 undergraduate and 4,049 graduate students.

Graduate students who entered M.I.T. last year held degrees from 358 colleges and universities, 206 American and 152 foreign. The foreign student population was 1,481 representing 17 percent of the total enrollment. The foreign students were citizens of 92 countries.

Degrees awarded by the Institute in 1975-76 included 1,049 bachelor's degrees, 862 master's degrees, 94 engineer's degrees, 390 doctoral degrees — a total of 2,395.

The number of women at M.I.T., both graduate and undergraduate, has increased continuously. In 1975-76, there were 1,255 women students at the Institute, compared with 1,111 in 1974-75. In September 1975, 177 first-year women entered M.I.T. representing 15 percent of the entering class. In 1975-76, a total of 257 degrees were awarded to women.

STUDENT FINANCIAL AID

During 1975-76 the student financial aid program was again characterized by increases in total awards, in loans made, and in the amount of scholarship assistance. There was a significant increase in the number of individuals assisted.

A total of 2,011 undergraduates who demonstrated the need for assistance (45 percent of the enrollment) received $4,299,341 in scholarship aid and $2,752,917 in loans. The total, $7,052,258, represented a 22 percent increase in direct aid over last year.

Scholarship assistance was provided by the scholarship endowment in the amount of $2,061,136, by outside gifts for scholarships in the amount of $805,024, and by direct grants to needy students totaling $857,515. Scholarship assistance from M.I.T.'s own operating funds was provided to the extent of $410,859. The special program of scholarship aid to minority group students represented an additional $164,807 from specially designated funds. An additional 377 students received direct grants from outside agencies, irrespective of need, in the amount of $892,444. Outside scholarship support thus totaled $2,554,983, another substantial increase over last year's total. A significant portion of the increase was again due to increased funding of the Federal government's grant-aid program. The undergraduate scholarship endowment was aided by the addition of new funds which represented an increase of $1,452,992 and which raised the principal of the endowment to $23,456,107.

Loans totaling $2,752,917 were made to needy undergraduates. Of this amount $872,249 came from the Technology Loan Fund, $1,873,918 from the National Defense Loan Fund, and the remainder from other M.I.T. loan funds. An additional $500,157 was obtained by undergraduates from state-administered Guaranteed Loan Programs and other outside sources.

Graduate students obtained $1,140,999 from the Technology Loan Fund. Of this total, $462,428 was loaned under the Guaranteed Loan Program and qualified for Federal interest subsidies and guarantees. The total loaned by M.I.T. to both graduate and undergraduate students was $3,915,771, an increase of $647,614 over last year's total.

CAREER PLANNING AND PLACEMENT

The past year was a busy one for the Career Planning and Placement Office, which means that it was generally a good year for graduating students. A total of 240 employers came recruiting — more than in any year since 1969-70 — and 854 students had 4,295 interviews. As usual, the majority of students looking for jobs were graduate students. While in some fields — notably the construction industry — one would have liked to see more employment activity, in other fields employer interest exceeded student interest. A third or so of the firms which canceled visits did so because not enough students had signed up to see them.

Two classes of students who wished they could take more advantage of the presence of so many employers on campus were those interested in summer jobs and foreign students interested in working in this country after graduation. The Office gave to the visiting recruiters some 900 resumes from students who wanted to talk with them but whose backgrounds did not fit with the employers' stated requirements. A good number of these were students seeking summer employment or were foreign students. If returning prosperity lowers the barrier which now prevents most foreign students from working in this country after graduation, and persuades more firms to hire students for the summer, we shall probably again see the sort of interview activity which was commonplace a decade ago. In 1965-66 some 1,731 students, United States and foreign, had a total of 7,374 interviews for permanent and summer employment.

Alumni activity in the Office reflected a gradual improvement in the market for experienced individuals over the year before. The number of alumni registering declined from 629 to 522, with a higher percentage of younger alumni — 20 to 30 years old — requesting assistance (up to 10 percent from the previous year). Job openings listed with Alumni Career Services totaled 1,519, practically on a level with the year before. The strongest demand, as usual, was for individuals with less than 10 years of experience. The Office continued to work with alumni who came in (or wrote) to discuss their career without registering themselves as job candidates.

FINANCES

As reported by the Vice President for Financial Operations and the Treasurer, the total financial operations of the Institute, including sponsored research, increased from the level of 1974-75. Educational and general expenses — excluding the direct expenses of departmental and interdepartmental research, and the Lincoln Laboratory — amounted to $110,259,000 during 1975-76, compared to $103,152,000 in 1974-75. Reflected in the finances of the Institute was the decrease in the use in operations of unrestricted funds to $6,493,000, compared with $9,005,000 the preceding year, which included a drawdown of the Research Reserve in the amounts of $240,000 in 1975-76 and $480,000 in 1974-75.

The direct expenses of campus departmental and interdepartmental sponsored research increased from $64,992,000 to $71,852,000, and the direct expenses of the Lincoln Labora-

tory's sponsored research increased from $72,922,000 to $81,737,000.

The construction program of the Institute continued to make progress in 1975-76, with the book value of educational plant facilities increasing from $197,513,000 to $201,822,000.

At the end of the fiscal year, the Institute's investments, excluding retirement funds, students' notes receivable, and amounts due from educational plant, had a book value of $319,878,000 and a market value of $401,006,000. This compares to book and market totals of $313,624,000 and $376,061,000 last year.

GIFTS

Gifts, grants, and bequests to M.I.T. from private donors increased from $20,282,000 in fiscal year 1974-75 to $22,393,000 in fiscal year 1975-76. The latter figure includes unrestricted direct gifts to the Alumni Fund of $1,334,000, which constituted part of the total of $4,025,000 reported by the Alumni Fund in 1975-76.

PHYSICAL PLANT AND CAMPUS ENVIRONMENT

With the completion and occupancy of the new West Campus Undergraduate House in August 1975 and the Ralph Landau Building (Chemical Engineering) in January 1976, the series of major building projects which started with the Second Century Fund capital construction in the early 1960s came to an end.

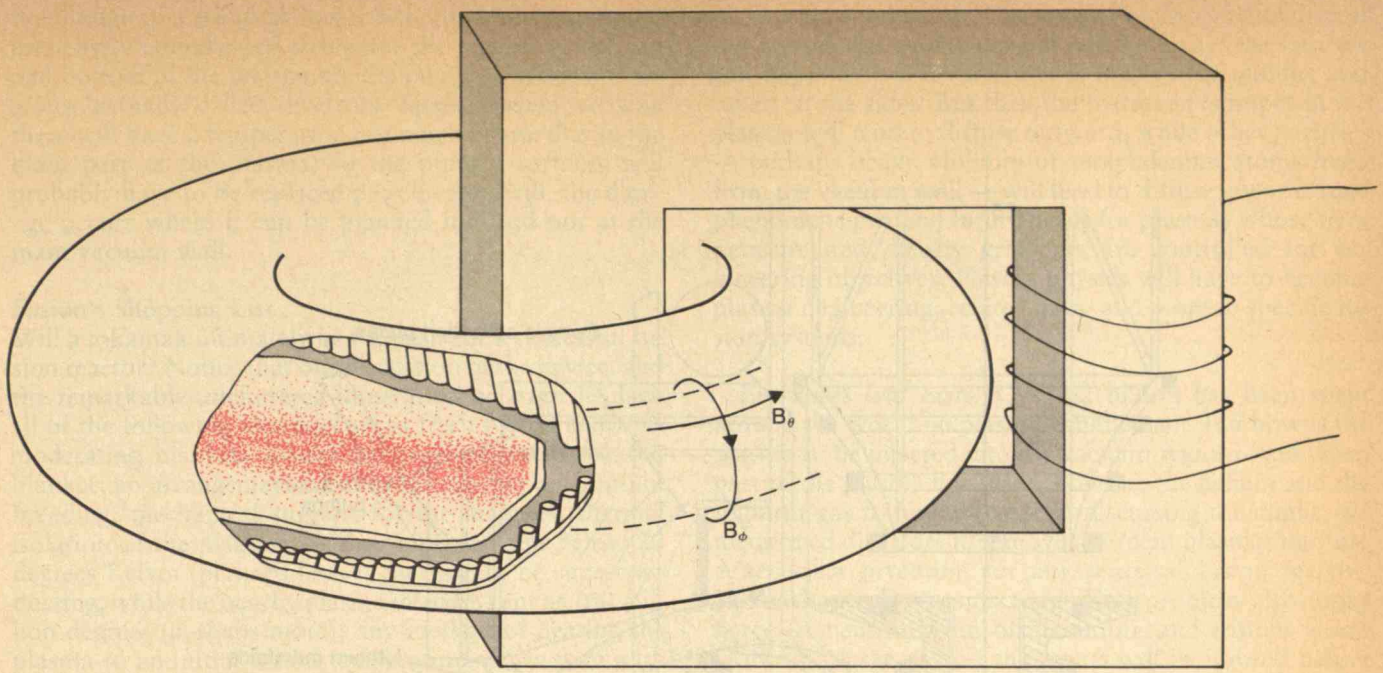
The new West Campus House is the first M.I.T. dormitory to be air-conditioned and provides accommodations for 297 students in six separate living groups. The facility was designed to serve as a primary housing resource for Summer Sessions and conference guests.

Bexley Hall is undergoing a major rehabilitation effort this summer — renovating all bathrooms and kitchens, replacing the electrical, plumbing, and gas systems, upgrading the heating system, installing a new roof, and adding storm windows. This work was started early in June and will be completed in time for occupancy for the fall term. The only remaining new construction to be initiated during the year was the addition of two building bays and a finger pier to the Sailing Pavilion.

Design work is in progress on a one-story 13,000 square feet interim animal care facility proposed for a site on Vassar Street between the Cyclotron Building and the Parsons Laboratory. An associated project scheduled to go into design later this year is the rehabilitation and modernization of existing animal facilities in the Whitaker and Ford Buildings. Phase I of the proposed new Athletic Facilities adjacent to Rockwell Cage is currently in the design/development stage. It is planned to include an ice skating rink which also may be used for graduation exercises and other large functions, and a fieldhouse with an indoor running track. Design was initiated in spring, 1976 on 4,000 square feet of additional laboratory facilities for the Center for Cancer Research in the Seeley G. Mudd Building.

Larger renovation and renewal projects completed during the year were offices for the Center for Policy Alternatives in the Webster Building on Amherst Street, student space and offices for the School of Architecture and Planning in Buildings 7 and 10, and the partial new tenancy of the Medical Department in Building 12, formerly occupied by the Department of Chemical Engineering. In addition, special efforts were made to upgrade lounge spaces in several of the dormitories. These projects, planned with the residents of each house, range from minimal repair and replacement to total redecorating and refurnishing.

Finally, the Housing Office has continued to add to the sprinkler systems in the corridors of all high-rise buildings, completing Eastgate, Tang Residence Hall, and the towers of Westgate and MacGregor House this year. This program, run in conjunction with the Safety Office, will continue next year.

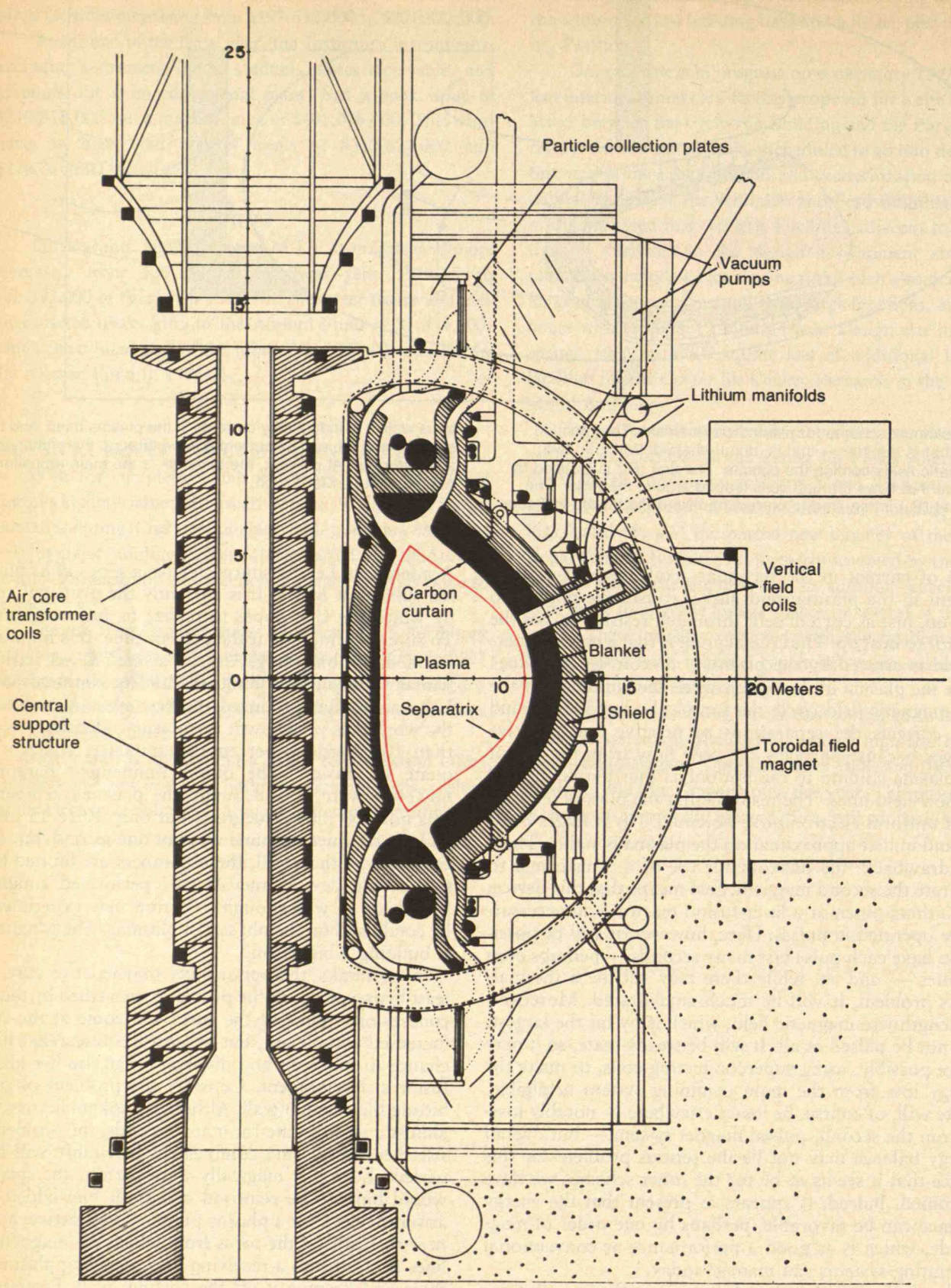


The tokamak scheme for plasma confinement. The reaction chamber is toroidal — that is, donut-shaped. Within it, two magnetic fields confine the plasma. The first (B_θ) is induced by current that flows through coils looped around the torus. The second (B_ϕ) is required to correct particle drifts toward the outer torus wall. It is induced by currents in the plasma itself, and those currents are induced by current flowing through the primary coil of a transformer. At present, the tokamak is the main repository of American hopes for fusion.

pulse of current in the secondary coil. Here, it induces current in the plasma; and also it causes the plasma to heat up, just as current sent through a resistor causes the resistor to heat up. The crucial point is that a new magnetic field is created by the plasma's motion. Its field lines circle the plasma in the same way as the windings for the first magnetic field circle the torus cylinder. This second field corrects the separations of positive and negative charges because particles can now flow from the top of the plasma column to the bottom as they gyrate around the new field lines. The result is that the plasma tends to be of uniform electromotive potential. No voltages build up, and in first approximation the plasma is stable. There is a drawback: the unavoidable use of a transformer to generate the second magnetic field means that this device, like a theta-pinch or a laser-fusion reactor, will necessarily be operated in pulses. Here, however, it will be possible to have each pulse last many seconds — perhaps even minutes — and so, while there may still be a thermal-stress problem, it will be much ameliorated. Moreover, the lengthwise magnetic field, which is by far the largest, will not be pulsed at all. It will be steady-state, so it may prove possible, using superconducting coils, to make the energy loss from the main confining system negligible. There will, of course, be losses elsewhere — notably losses from the second, pulsed magnet system — but overall energy balance may not be the serious problem for this device that it seems to be for the other schemes we have examined. Indeed, it appears at present that the energy balance can be favorable, perhaps by one order of magnitude, which is as good a performance as conventional generating systems can manage today.

The device we are now discussing is the so-called tokamak, first conceived in the U.S.S.R. and liberally described by the Soviets throughout the mid-1960s, but neglected by the U.S. until early in 1969, when the late Academician Lev Artsimovich gave a series of lectures on the subject at M.I.T. It is currently the principal vehicle by which the U.S. hopes to realize its fusion ambitions. To some extent, and at the present time, this hope seems justified. For one thing, Alcator, a small device with a tokamak configuration built at M.I.T.'s National Magnet Laboratory, has produced the best plasma confinement the world has yet known: the plasma's density was more than 10^{14} particles per cubic centimeter, which is adequate for fusion. The other confinement parameters, however, were not adequate: the plasma's temperature was not 100 million degrees, but only 10 to 15 million, and the confinement time was not one second, but only a twentieth of that. Still, these numbers are limited by the size of the device, and Alcator performed roughly as hoped for — well enough to permit new experiments to be conducted on the physics of plasmas. The Magnet Lab is building a bigger one.

In tokamaks, the opportunity may exist to cure, or at least bypass, some of the problems unearthed by the other conceptions. Some of the cures will come at the cost of increased complexity, but at least the researcher has the chance to move on and discover what else lies ahead in fusion's development. Consider the problem of plasma hitting the vacuum wall. Although a tokamak may run at almost a steady-state for many seconds, the problem persists because plasma confinement inevitably will be imperfect. Even if it magically were perfect, the spent fuel would have to be removed and fresh fuel added. Thus arises the need for a plasma pump — in practice, a region near the walls of the torus from which the magnetic field lines peel off into a receiving area, carrying plasma with them and keeping it off the vacuum wall. Provision for such a pump is included in the tokamak reference design called UWMAK III, prepared at the University of Wisconsin and shown on page 38. Here, the simple concep-


25
15
10
5
0
Particle collection plates
Vacuum pumps
Lithium manifolds
Vertical field coils
Air core transformer coils
Carbon curtain
Plasma
Blanket
10
15
20 Meters
Separatrix
Shield
Central support structure
Toroidal field magnet

tual design of a tokamak has grown into an immense and immensely complicated structure; the regions at the top and bottom of the plasma are the pump or graveyard regions, actually called divertors. Spent plasma arriving there will have a temperature not much below that in the main part of the plasma, so the pump's surfaces will probably have to be replaced periodically. Still, the damage occurs where it can be planned for, and not at the main vacuum wall.

Fusion's Shopping List

Will a tokamak ultimately be the basis for a successful fusion reactor? Notice that our discussion of the device, and the remarkably uncluttered illustration on page 37, lack all of the following: An injector of fresh fuel; a neutron-moderating blanket; a heat-removal apparatus for the blanket; an arrangement for tritium recovery and tritium breeding; mechanical support for the magnets; thermal isolation of the magnets — they must be kept below 20 degrees Kelvin (perhaps less) if they are to be superconducting, while the nearby plasma must be kept at 100 million degrees (perhaps more); any method of heating the plasma to an initial fusion temperature, other than with the transformer (and it can be shown that the resistance heating of the plasma by transformer-induced current is by itself insufficient); any arrangements for safety, access, or repair. In fairness to tokamaks it should be said that many of these problems are design-independent: they and others will apply in some form to any fusion reactor. Here is our shopping list:

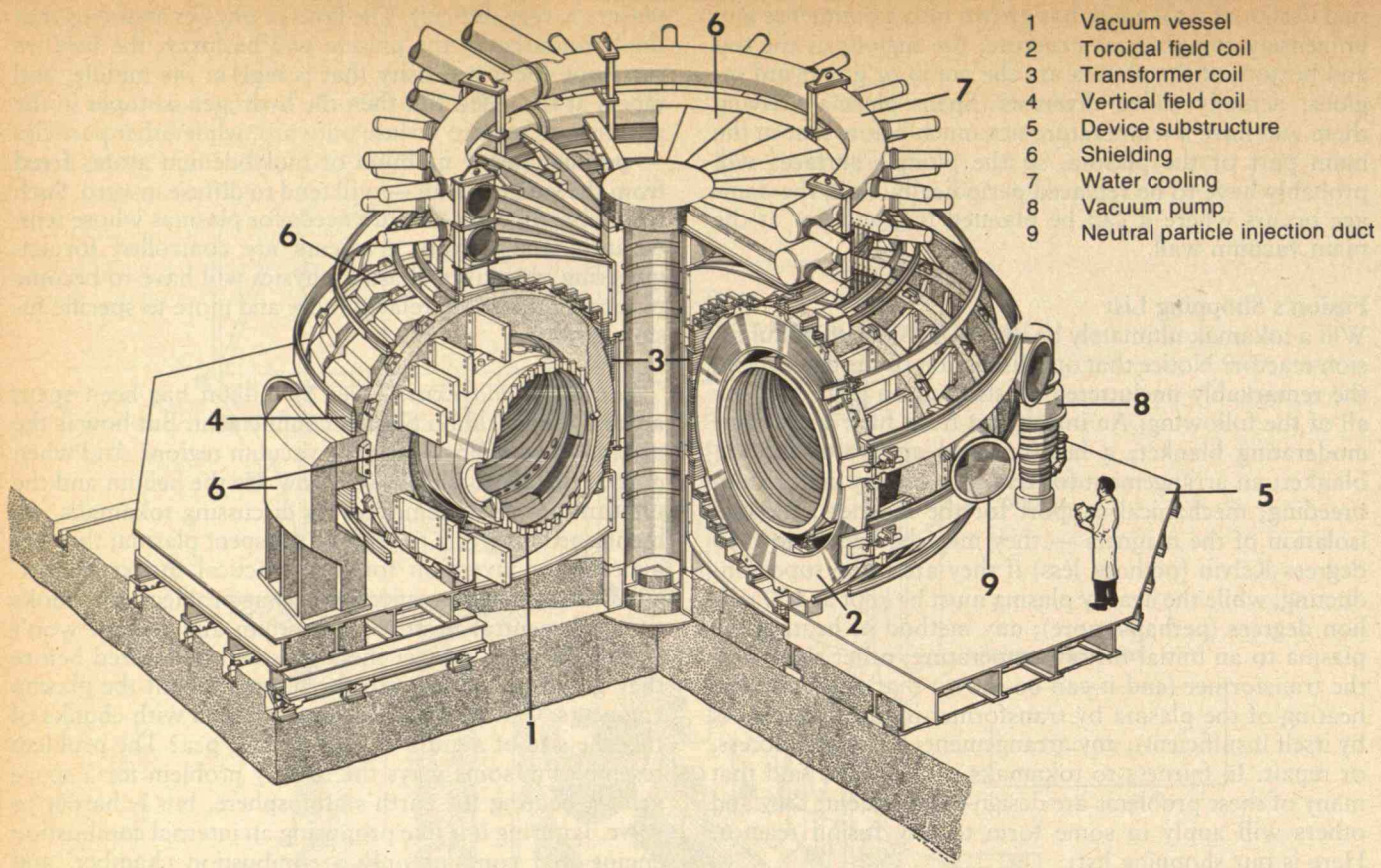
Plasma engineering. Ionized gas is not enough. It must have the right density and the right temperature in the right places. Moreover, it must be highly pure, in part for reasons we touched upon earlier: impurities cool the plasma and may, after charge-exchange reactions, damage the vacuum wall. An additional reason is that scattering of the plasma's particles by the massive particles typical of impurities leads to loss of energy from the plasma by electromagnetic radiation — for example, by so-called *Bremmsstrahlung* (literally braking radiation), created by deceleration of electrons. Keeping impurities out of a plasma is very difficult. The laws of physics assure us that the boundaries of the plasma will be fuzzy; the best we can hope for is a density that is high in the middle, and tapers at the sides. But then the hydrogen isotopes in the plasma will tend to diffuse outward, while other particles — perhaps heavy niobium or molybdenum atoms freed from the vacuum wall — will tend to diffuse inward. Such phenomena portend future needs for plasmas whose temperature and density gradients are controlled for engineering objectives. Plasma physics will have to become plasma engineering, related more and more to specific fusion systems.

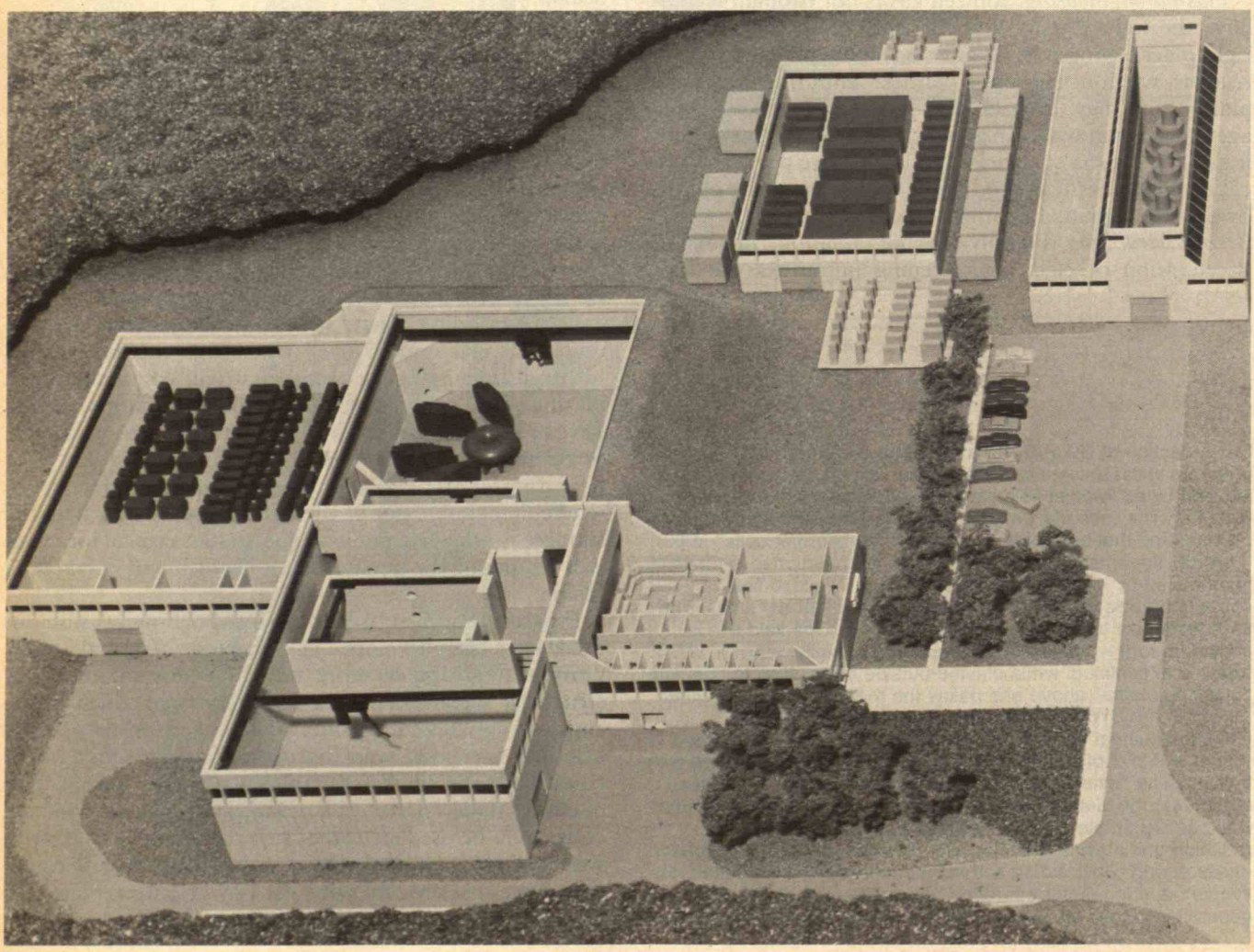
Entrances and exits. Over $2 billion has been spent around the world on plasma confinement. But how is the plasma to be injected into the vacuum region? And when part of the plasma has fused, how are the helium and the unburnt gas to be removed? In discussing tokamaks, we mentioned divertors to remove the spent plasma; they are a necessary invention for any practical fusion reactor. What about plasma injection? That problem also looks fierce. A neutral beam of deuterium and tritium won't work in a large device; the atoms will be ionized before they get deep enough into the plasma to suit the plasma engineers. Can injection be accomplished with chunks of fuel the size of a grain of rice, or of a pea? The problem resembles in some ways the reentry problem for a space vehicle nearing the earth's atmosphere, but is harder to solve. Ignoring it is like proposing an internal combustion engine that contains only a combustion chamber, and lacks intake valves.

Materials. They must be resistant to an immense flux of radiation, neutrons, and heat, and also to strange kinds of corrosion and immense pressures; if the reactor operators had to replace the insides once a week, even if it could be done quickly, the reactor would soon be an economic loser. It will take years to find and develop new materials — longer, probably, than the optimists think, and the administrators in Washington proclaim. The vacuum wall, for example, faces an environment that is unimaginably hostile — an energy flux that is higher than anything else ever made, except a nuclear weapon in the process of exploding. There is serious danger that the vacuum wall will sputter away when high-energy particles hit it, dislodging heavy atoms that will contaminate the plasma. One might conclude that the vacuum wall will have to be outrageously thick if it is to survive many years of operation. On the other hand, thick walls give poor heat transfer and also capture large numbers of neutrons where they should not be captured. Developing a material suitable for the vacuum wall and similar critical locations will be one of the most difficult problems of controlling fusion.

Progress, however, is being made. High-nickel stainless steels have been developed at Oak Ridge National Laboratory that are much more radiation-resistant than any structural metals known a few years ago. Such alloys suggest that the energy flux in the reaction area could safely be increased, and that in consequence the reactor could be made smaller for the same power output. If it could be made smaller still, perhaps normally-conducting coils could be used instead of superconducting ones, with vast reduction in engineering complexity. But it might then have disastrously poor net power output. The true direction of progress is still uncertain.

Cross-section of UWMAK-III, a reference design for a tokamak prepared at the University of Wisconsin. The main magnetic field is induced by a "toroidal field magnet" looping around the reaction chamber. The secondary magnetic field is induced by current in the plasma, and that current is induced by "transformer coils" in the "central support structure." A third field, not mentioned in the text, is produced by "vertical field coils." Like the second field, it corrects particle drifts, and its magnitude is relatively small. The three fields act together to confine a plasma. One field line is shown (in red) — the so-called separatrix. Ideally, plasma within that line is confined, while plasma outside it is guided to "particle collecting plates" above and below the reaction chamber. Other details of the UWMAK-III design: The "blanket" contains a lithium-aluminum compound. The lithium is there only to breed tritium, not to cool the reactor. (Cooling is to be accomplished with helium.) The "shield" provides additional protection to outside structures; the blanket alone is deemed insufficient. The vacuum wall has a graphite curtain, intended to protect the wall from radiation and plasma particles. But graphite will trap atmospheric gases during construction and maintenance, and then pollute the vacuum during reactor operation. For problems of tokamaks generally, consult the text.


1 Vacuum vessel
2 Toroidal field coil
3 Transformer coil
4 Vertical field coil
5 Device substructure
6 Shielding
7 Water cooling
8 Vacuum pump
9 Neutral particle injection duct
6
7
6
3
4
8
6
5
9
2
1



The Tokamak Fusion Test Reactor (T.F.T.R.), to be constructed at Princeton University's Plasma Physics Laboratory. Over $200 million will be spent to build the device, with its associated facilities; and roughly the same amount will be spent on operating costs through the mid-1980's. The device is not a reactor; it represents an opportunity to create and experiment with a fusion plasma. "Neutral particle injection ducts" will continually introduce hot particles into the torus. Initially only light hydrogen will be used; toward the end of the experiment's life, a deuterium-tritium mixture may be tried. The bottom picture shows the entire laboratory complex. The torus is surrounded by particle injectors. The room to the left of the torus contains power supplies; the other adjoining room includes a hot cell for disassembly and maintenance of the experiment.

Reliability, Repair, and Accessibility. None of the present schemes is credible from this aspect, and in general, the larger and more complex systems rate lower. Again, the most critical item is integrity and possible repair of the vacuum wall. Recall that reactor operation will make it radioactive. The problem cannot be wished away until a fusion demonstrator stage: experience with acceptance of fission reactors shows that the efforts made to develop fusion reactors must include work on these matters, too, or power companies will not be interested.

Plasma confinement. It appears that simple magnetic mirrors will not work as fusion reactors, nor will fast-pulsed devices such as theta-pinches and systems using lasers. The tokamak configuration remains, but whether it is truly workable as a fusion reactor is not sure either. Fortunately, other ideas are appearing. One, still in its earliest stages of investigation, is the so-called bumpy torus, made by taking a set of coils such as those used in magnetic mirrors, and arranging them in a ring, like hoops in a circular croquet game. The plasma confined by this array takes on the shape of a string of sausages. It appears that a bumpy torus may correct the radial instabilities found in a single magnetic mirror, for the stability of a plasma depends on the average history of the particles within it — on the changing strength and orientation of the magnetic field sampled by the particles as they move. Moreover, particles would not be lost out the ends of a bumpy torus, for it has no ends. Finally, a bumpy torus could operate continuously, without pulsing, in the manner of a single magnetic mirror. The scheme is only one of a whole class of steady-state toroidal devices, most of them inadequately explored.

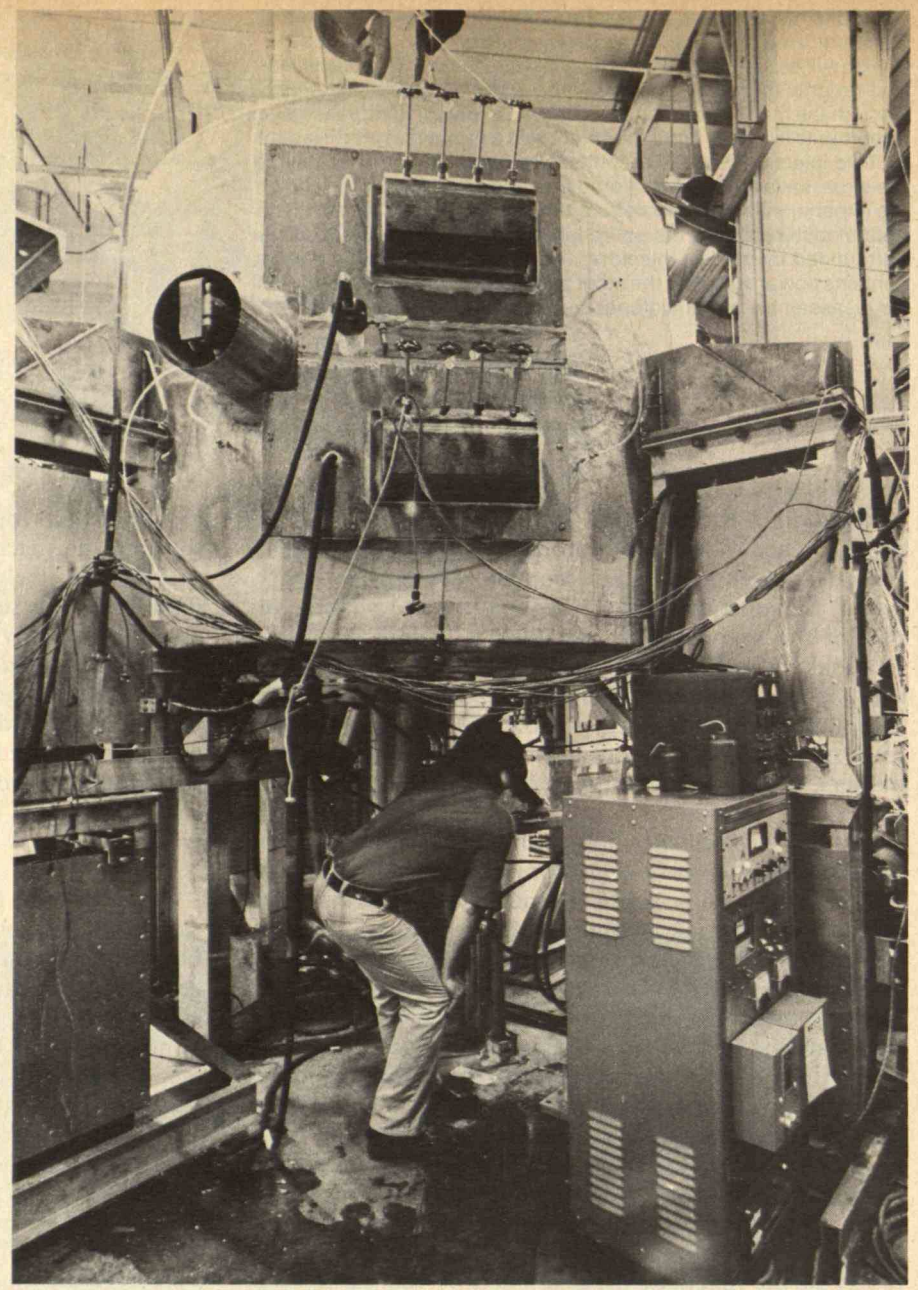
Tritium. The fact that it doesn't occur in nature received little attention until about 1960, because it had been a tacit assumption that, as we reported, one could always make it by using fusion's leftover neutron in a reaction with lithium. But this means that the fusion reactor must be a complicated breeder reactor from the start. The need for tritium (with its radioactivity) is lamentable, but the cross-sections for fusion reactions involving other light nuclei are far smaller than the cross-section for the deuterium-tritium reaction. Therefore, far greater values of density, temperature, and confinement time would be required to make the other reactions proceed at an appreciable rate. We noted all this earlier.

Now it may be that only a single gram of tritium will be reacting in a 50,000-ton fusion reactor at any one time. However, the burnup of nuclear fuel for each pass through the reactor will be only a few per cent, so the reactor will likely contain several kilograms of tritium, most of it being separated from the spent plasma and then recycled — all by a process not yet worked out. Perhaps some of the details are yet to be discovered, for controlling tritium is exceedingly difficult. The isotope is a form of hydrogen, and hydrogen diffuses through almost all metals useful for the reactor structure. Those metals that can contain hydrogen include platinum, which is too soft; tungsten, which is almost impossible to machine; and gold.

Lithium. Will there be enough deuterium and tritium to run a fusion-powered economy of the future? Deuterium, at least, is plentiful, as we have seen. To provide an environment in which tritium can be created, every fusion reactor will be surrounded by a lithium-containing blanket in which the reactions given on page 27 will occur. Therefore we turn to the question of lithium availability.

For the year 2000 it is estimated that an electric generating capability of up to 1,000,000 megawatts will be needed in the U.S. No megawatts in that year will be generated by fusion, but let us imagine similar energy demand at some later time. The potential world reserves of lithium are estimated at 2×10^7 metric tons, enough for 2.8×10^{14} megawatt-hours of electric power production. This is approximately a 30,000-year supply, seemingly enough to last through a long technological age. However, there are complications. First, the inventory of lithium in a fusion reactor must be fairly high, if the lithium reactions are to have a good chance to occur before the neutrons are absorbed elsewhere, perhaps by the structural material of the reactor. Second, liquid lithium (or a molten salt that contains lithium) may also be required to remove nuclear heat from the reactor. One might conclude that lithium will be in short supply for fusion reactors. One estimate is that about 9×10^5 metric tons will be required to begin operation of 1,000,000 megawatts worth of fusion reactors; this is a large drain on lithium resources, but could probably be met by a determined effort.

The lithium reserves quoted above do not include the lithium content of sea water (approximately two parts per million by weight), which is much larger but so far is very expensive to extract. Yet past experience shows that when a serious attempt is made to locate new reserves of previously ignored minerals, more will probably appear.



Alcator A, a tokamak constructed at M.I.T.'s National Magnet Laboratory. The device is small, but it confines a plasma of ionized hydrogen (that is, a gas of dissociated protons and electrons) within a magnetic field of eight Tesla (80,000 Gauss). This is more than twice the field strength attained within any other tokamak. Alcator is in fact designed for the study of plasma confinement at extremely high field strengths. A "C" version, now being planned, will attain 14 Tesla.

Plainly, the lithium resources could permit vastly more energy generation than petroleum ever did or coal ever will, before heroic measures need be undertaken to exploit dilute lithium deposits. Since complex civilizations have been built on fossil fuel, lithium availability should not be a barrier to fusion development; the supply is short only compared with the essentially endless supply of deuterium.

In view of all the difficulties, we ask again: Is civilization mad to pursue controlled nuclear fusion? And are all the moribund concepts — laser fusion, simple magnetic mirrors, theta-pinches — a sign of the expensive folly? The answer to the second question is easy, and it is definitely no. By such trials and errors, we have come as far as we have. The experiments have taught us about high-density, high-temperature plasmas, about plasma instabilities, about the damage that high-energy particles and radiation cause in various materials. In any event, the work typifies the way in which the development of high technology must proceed.

As fusion schemes come and go, it is hard to distinguish between a valuable stepping-stone that lets us advance, and a corner-stone of the final fusion edifice. How does one tell when the final concept arrives — the one upon which all further efforts ought to be focussed? One cannot know in an absolute sense. Judgment must enter. In our view, the field is still open; the best fusion concept has yet to be recognized. Meanwhile, however, the Energy Research and Development Administration has been making a long-range plan for fusion, and at first (in its draft versions, released for comment this spring) gave the impression that it knew pretty well what a fusion reactor will look like. The drafts included trial plans describing in inappropriate detail the development of an "experimental thermonuclear reactor" — an extrapolation, evidently, of current reference designs. "Start fabrication of magnet coils"; "Complete installation of magnet coils"; "Start test" — this last step in July of 1989! Taken literally, E.R.D.A.'s exercise suggested to some that the fusion program is fixed in direction through the late 1980s, and

generated vigorous comment in the scientific literature.

Of course, extrapolation of current reference designs would lead to fusion monstrosities: structures 50 meters in diameter, cooled by liquid lithium flowing behind an acre of wall a millimeter thick, magically maintained by remote machinery. The superconducting magnets that surround the reaction region, as presently designed, would make it inaccessible for any kind of servicing by an electric utility company. The minimum feasible size of such a reactor might be 10,000 megawatts, too much in one unit for any electric utility. If fusion reactors look like that, officials of the utilities are saying, then we don't want them.

The plans now presented by E.R.D.A. show a welcome flexibility, and no fixed view of what a real fusion reactor will look like. Indeed, the first page points out in effect that such plans are meant to be self-destructing: five years from now we hope to know much more than we do now, just as now we know much more than we did five years ago. So we live in hope.

The Prospect for Fusion

The growth of nuclear power fluctuated greatly in the period preceding the early 1970s. Because of hopes for cheap nuclear power, a flurry of orders for fission reactors came in during the mid-1960s, at very low quoted prices — one figure was $130 per kilowatt of installed generating capacity. Reality soon caught up with both the utilities and the reactor manufacturers; it was realized that nuclear power would be more expensive, and that all the faults had not been eliminated. Then the orders declined. They picked up again only as fossil-fuel power began to look more expensive, partly because in the early 1970s it came under increasingly strict environmental regulation; virtually every coal-fired electric power plant in the Northeast either closed down or switched to low-sulfur oil. Finally, in 1973, the predictions of fossil-fuel difficulty became known to all, and about 50,000 megawatts of nuclear power-generating capacity were ordered. Continuing fossil-fuel price rises in 1974 reinforced the trend to nuclear power. However, the plants now cost up to $1,000 per kilowatt, in 1980s money, for 1980s delivery. The electric utility industry is in real danger of economic collapse; the commitments to new nuclear plants (180 gigawatts, more or less) could break them.

Nuclear fission has had a number of successes and a number of failures. Some of the failures have been organizational in nature — there has been insufficient self-criticism and insufficient internal responsibility. Don't rock the boat, various committees seem to have decided. Give us the money and we'll get around the problems somehow, but let's handle it secretly. This strategy doesn't work in the long run: criticism will come anyway, and when it does, people will grumble even more, asking, "Why didn't you tell us that before?" Surely it must be possible for a society to face a difficult problem, knowing that an effort must be made though a happy outcome is uncertain. Each citizen seems perfectly able to understand the situation. But when people become members of committees, they don't dare say those things that committee-members should say to one another.

In efforts to control fusion, some of these problems have already appeared. For example, fusion research was sold for years on the basis that fusion reactors were just around the corner. In the 1950s, engineers were making designs of fusion reactors that employed copper coils and steam pipes instead of the very exotic materials that we now know will have to be developed. At Princeton, researchers planned to build four models of the Stellerator — a fusion device of olden days. They proposed Models A, B, C, and D, each bigger than the one before, and they spent $30 million on C. Model D was to have been the industrial demonstrator, but it was never built, because Model C led to new plasma science, not to confirmation of the old. In that way, these expensive experiments showed researchers that an entire field — plasma physics — had yet to be developed. It took about ten years, and great credit accrues to the plasma physicists for managing the feat — in essence, for showing how to contain a Promethian fire. After all, confining a plasma is like taking all the air in a room, forcing it into the center of the room without touching it, and heating it to a temperature of several million degrees. A principal difficulty was expecting and predicting too much too soon. Bit by bit, realism now works its way in. Princeton now plans to build the TFTR — the tokamak fusion test reactor — at a cost of $228 million. It is meant to be operational in 1981 or 1982, but it will have no engineering for energy recovery. Still, it will (one hopes) confine a plasma well enough for fusion to occur, were it fueled with a deuterium-tritium mixture. (Doing that, however, would cause the TFTR to become radioactive after very few test firings.)

The design that currently gets the most money is the tokamak, which has many problems. But at least the difficulties seem to be evenly spread: the confinement time, the divertors that pump the plasma in and out, start-up, access, wall damage, repairability. . . .

Many things must be done, and failing to do any principal one of them could kill the entire effort. Consider this fable: If you, as the director of an energy utility in the 21st century, had a fusion reactor constructed according to 1977 designs, and a pinhole puncture developed in its vacuum wall, you'd have to move to Antarctica, and you'd be pursued, not necessarily by radiation but surely by outraged investors. Technological problems such as vacuum-wall integrity may yet be the critical ones in controlling fusion.

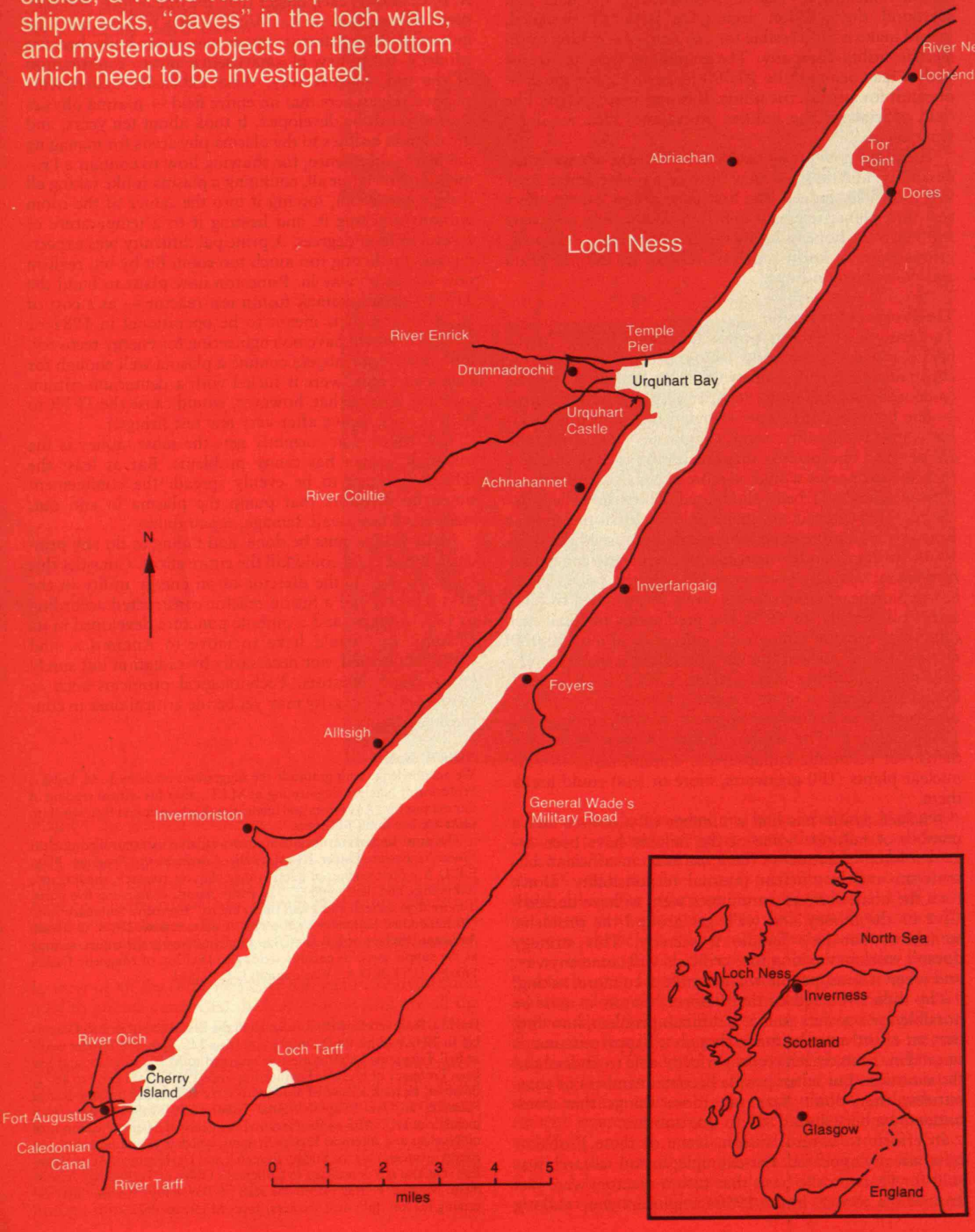
Authors' Note

We acknowledge with gratitude the suggestions made by L. M. Lidsky, Professor of Nuclear Engineering at M.I.T., after his critical reading of our manuscript. Any errors and infelicities that have found their way into print are our fault, of course.

The most important document now available on controlled nuclear fusion is *Fusion Power by Magnetic Confinement: Program Plan,* E.R.D.A.'s final version of a long-range plan for research, shading into technology and development. The entire report, comprising five parts, is more than an inch and a half thick, but its "Executive Summary" and "Volume One: Summary" are useful as an overview. Dr. S. O. Dean, Assistant Director of E.R.D.A., has kindly offered gratis copies, so long as the supply lasts, to persons writing to Division of Magnetic Fusion Energy; U.S.E.R.D.A.; Washington, D.C. 02545.

David J. Rose received his B.A.Sc. from the University of British Columbia in 1947 and his Ph.D., in physics, from M.I.T. in 1950. After work at Bell Telephone Laboratories, he returned to M.I.T. in 1958, and has been Professor of Nuclear Engineering since 1960. From 1969 to 1971, however, he took a leave of absence to serve as Director of Long-Range Planning at Oak Ridge National Laboratory. Professor Rose is a member of CONAES — the National Academy of Sciences' Committee on Nuclear and Alternate Energy Systems, which is preparing a study on energy strategies for the Energy Research and Development Administration. He also is a consultant to Congress's Office of Technology Assessment. **Michael Feirtag** joined the staff of *Technology Review* after receiving his S.B. (physical sciences) from M.I.T. in 1972.

Sonar studies in Loch Ness have revealed some startling discoveries underwater — large, ancient stone circles, a World War II airplane, shipwrecks, "caves" in the loch walls, and mysterious objects on the bottom which need to be investigated.



Martin Klein
Charles Finkelstein
Klein Associates, Inc.

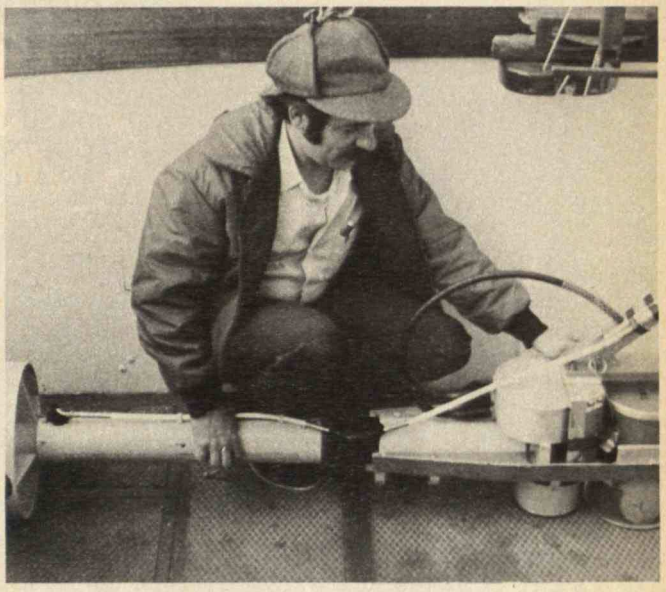
Sonar Serendipity in Loch Ness

During the summer of 1976 we at Klein Associates, Inc. had the privilege of participating with the Academy of Applied Science in a continuing investigation of the depths of Loch Ness. In our original work in the loch in 1970, we had made some important discoveries. We had proven to our own satisfaction that there are large, moving objects in the loch. We had observed on our sonar deep schools of fish which could, perhaps, give ample food supply for one or more large animals in the loch. We had also observed that the steep-sloping walls of the loch had very rugged terrain with sharp ridges and deep undercuts — possible "caves" or hiding places where a large creature could elude our photographic and sonar "eyes."

Other sonar researchers at the loch had shown, on many occasions, that there are large moving objects. The famous photographs made in 1975 by Robert Rines (*see "Search for the Loch Ness Monster,"* Technology Review, *March/April, 1976, p. 25)* renewed our enthusiasm, and we continued to ponder the challenge of how we could use our sonar this year to obtain more conclusive proof of the existence of the famous monster. In December, 1975, Klein was part of the Academy team which addressed the Preservation Committee of the House of Commons in London. We presented the evidence obtained to date, and we put forth the view that if there is a Loch Ness monster, it should be protected as an endangered species! At that meeting, Dr. Christopher McGowan, paleontologist with the Royal Ontario Museum in Toronto, expressed his enthusiasm for the controversial Rines photographs. However, he observed that only some actual samples of a carcass or bones of the animals would give positive proof. The idea occurred to us that our sonar might have enough resolution to detect whole carcasses or skeletons on the floor of Loch Ness.

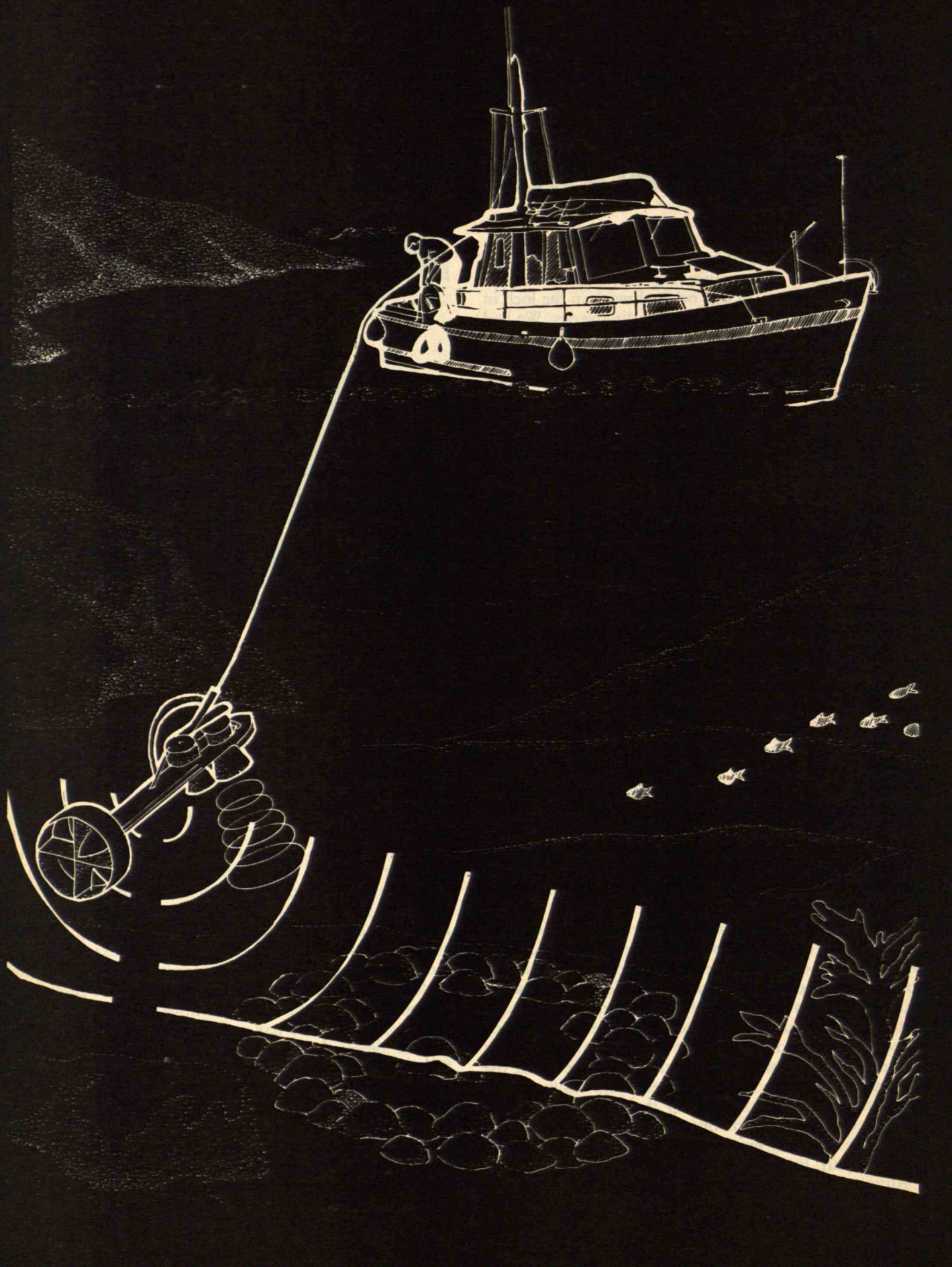
We suggested to McGowan that we should experiment to see if bones underwater would be an adequate acoustic target for our sonar. We offered to use our small research boat in a lake near our laboratory in Salem, New Hampshire. McGowan flew down from Toronto with a large suitcase full of mammoth bones. Finkelstein, an experienced diver, placed the bones in a pattern at the bottom of the lake. The sonar towfish was then towed over the area, and McGowan and Finkelstein were easily able to detect the bones. Encouraged by these experiments, we proceeded with plans for our expedition to Loch Ness. Our 1976 Academy expedition to Loch Ness was sponsored, in part, by the *New York Times.*

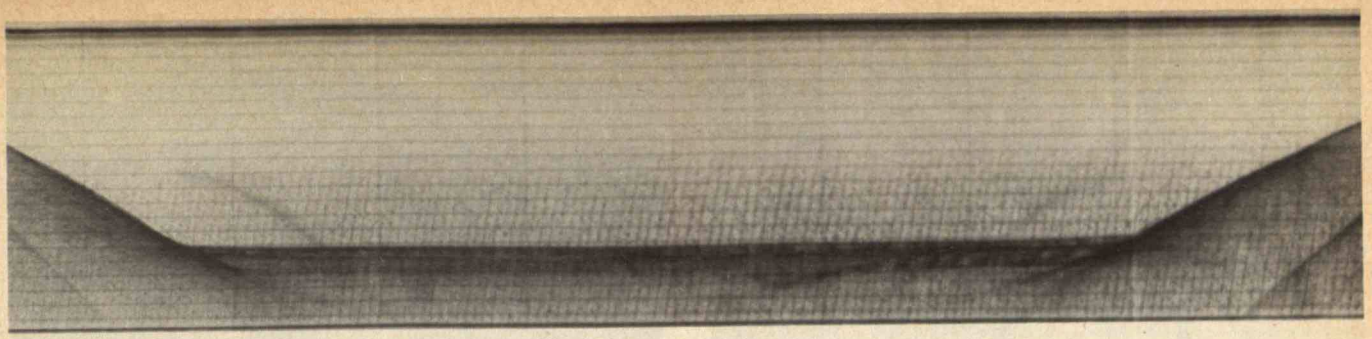
Although our time in Loch Ness was to be limited, we planned to run four sonar experiments. The first was to use our new sonar sub-bottom profiler to probe the sediments in the deep part of the loch. The second was to use our side scan sonar to further study the structures in the walls of the loch. Our third and possibly most important experiment was to search the bottom of the loch for carcasses or skeletons. We realized that such a search would have a very remote possibility of success, but we wanted to give it a try. Our sonar had been successful in many areas of the world finding difficult targets, and we had confidence in the technique. We also planned to continue our "fixed-mode" experiments by placing a sonar in the middle of Urquhart Bay looking out across the entire bay to make a "sonar curtain." We hoped that anything entering or leaving the bay would have to cross this path and be detected. We planned to set up our sonar in "fixed-mode" during the nights with the expedition cameras actually in the sonar beam. This way we might be able to detect when objects were near the camera, to improve our possibility of obtaining a photograph. Since we knew our time would be short, we planned to work long days with "mobile" experiments during the day and "fixed-mode" experiments at night.



Author Martin Klein, president of Klein Associates, Inc., with the towfish for the HYDROSCAN Side Scan Sonar/Sub-Bottom Profiler, as used in Loch Ness. (Photo by Charles Finkelstein)

The side scan sonar system consists of a towfish, which sends out powerful sound pulses and receives echoes from the bottom; an onboard recorder; and a tow cable. The Klein sonar used to search Loch Ness had, in addition to the left- and right-hand side sonar beams, a third beam aimed straight down to penetrate bottom sediments.





A sub-bottom profile of the cross-section of the bottom of Loch Ness, using a Klein Associates 3.5-kHz sonar. Each scale line represents 15 meters of depth. The "extensions" of the steep sides beneath the sediments appear to be false "side echoes." (Copyright Klein Associates, Inc. and the Academy of Applied Science.)

New Sonar Eyes

The equipment which we brought to Loch Ness in 1976 was our new combined side scan sonar/sub-bottom profiler system. Except for some local studies and some work with the U.S. Navy, this was the first major field expedition for this system. The system has three basic elements — a towfish, a tow cable and a graphic recorder. On page 46 is an artist's conception of our side scan sonar system.

The towfish contains transmitting circuitry to energize transducers which project high-intensity, high-frequency bursts of acoustic energy in fan-shaped beams. These beams are narrow in the horizontal plane and wide in the vertical plane and project along the sea floor on both sides of the moving towfish. Objects or topographic features on the sea floor produce echoes which are received by the transducers. In the new system, a third transducer has been added to the towfish. This unit has a lower frequency to penetrate the bottom sediments. It has a conical beam which points vertically into the bottom. For our work in Loch Ness, the side scan had a frequency of 100 kiloHertz (kHz), a horizontal beam angle of one degree, and a pulse length of 0.1 millisecond. Our profiler used a frequency of 3.5 kHz, a conical beam of 50 degrees and a pulse length of 0.4 milliseconds.

The echoes received from the transducers are amplified in the towfish electronics and sent up the tow cable to the shipboard recorder. For our work in Loch Ness we used a 100-meter length of a special lightweight cable which has a strain member made of duPont Kevlar which has the strength of steel, but only a small fraction of its weight.

The Klein recorder processes the incoming echoes and prints them on a special three-channel writing mechanism. This creates a permanent, continuous graphic record of a wide path along the sea floor as well as the sub-bottom layers below the sea floor. The recorder places each echo side by side so that a coherent visual picture of bottom formations is built up from successive echoes. The side scan records frequently resemble large-scale aerial photographs. Normally, two of the recorder channels are used to display the left and right side scan echoes and one channel is used to display the results from the bottom profiler. However, at Loch Ness, we ran some interesting experiments by disconnecting the profiler and by feeding one of the side scan channels into two recorder channels. Klein Associates has been experimenting with a variety of signal processing techniques to better visualize the sonar "picture." We used some of these techniques to bring out the fine details of the sonar signals and to help interpret difficult signal areas.

Surveying the Bottom

Finkelstein arrived at the expedition site in Drumnadrochit, Scotland, on June 12, 1976, and Klein arrived on June 27. Unfortunately our equipment was held up in customs and nearly a week was lost.

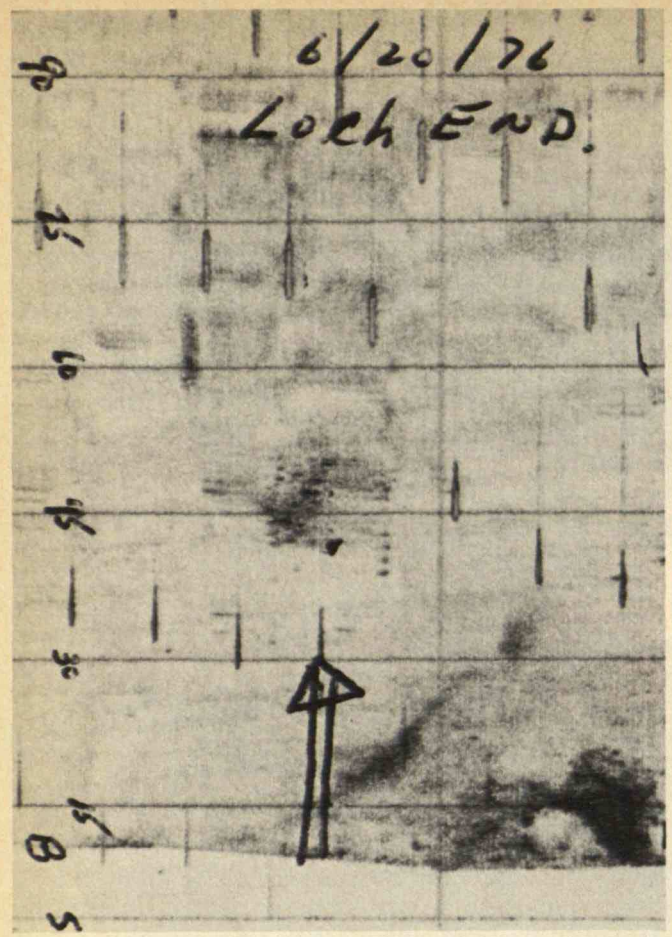
Upon arrival, we were delighted to find that Harold Edgerton of M.I.T. was already running "fixed-mode" sonar experiments at Temple Pier using another EG&G side scan sonar system *(see box p. 54)*. With this portion of the experiments in good hands, we were able to concentrate on our other experiments.

The sonar equipment was set up aboard the survey vessel *Malaran*. The ship, 33 feet long with power by twin diesels, proved to be perfect for our survey operations. We set up two automobile wheel rims in the stern over which we payed out the sonar cable. Our equipment was operated using two standard automobile batteries for power.

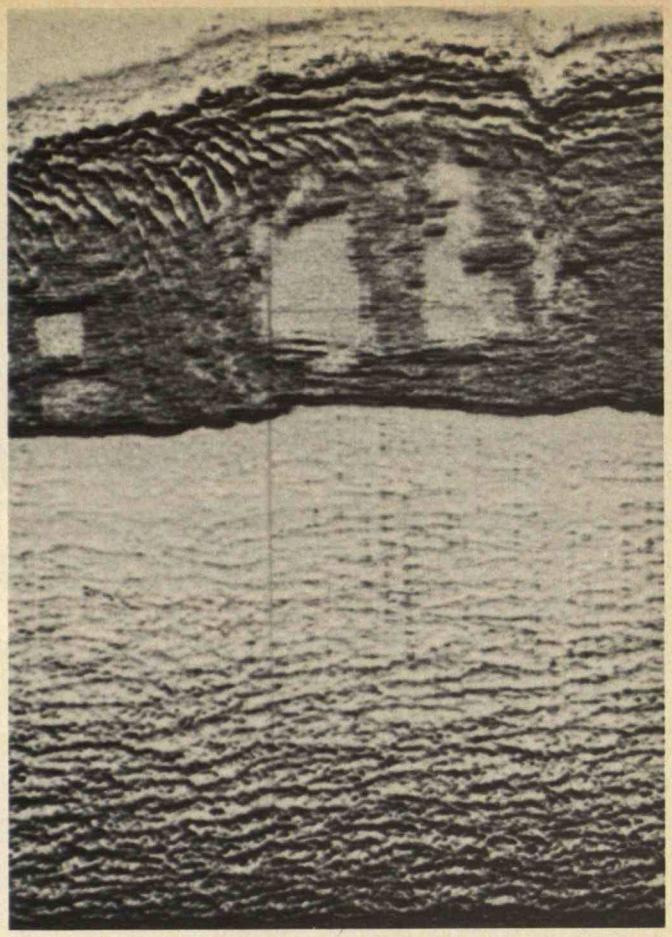
An important part of our survey operations was navigation. We wanted to run organized survey lines and then be able to return to these lines as necessary to further study what a survey had uncovered. Sophisticated radio navigation schemes are often used for such surveys, but budget considerations did not allow for one of these systems. Instead, we set up a simple system using sighting compasses with the able assistance of a local surveyor, George Reid. Two compasses were used on the boat to sight land bearings. Fixes were taken every few minutes. Two land bearings, the ship's heading, and the time were all recorded while an event mark line was simultaneously placed on the sonar recorder trace. Then George Reid plotted the lines so we could see what areas we had covered and reposition the ship as necessary. We were assisted during the survey by Chris McGowan and by Jeffrey Thomason, a zoologist now also with the Royal Ontario Museum. Robert Needleman of the Academy and Jean Mooney of M.I.T. helped with survey coordination and data recording.

Profiling the Sub Bottom

One of our first experiments was to profile the bottom-sediment layers by making runs from east to west across the narrow part of the loch. We hoped to settle one major controversy — whether the bedrock under the loch is V-shaped, or a flat-bottomed U-shape. Some argued that the bedrock had retained its V-shape over the millenia, and that the flat bottom had been formed by sediment settling into the "V." Others said that the gouging action of the glaciers which filled the loch during the



The first unknown target picked up on the 1976 sonar search was investigated by diver Finkelstein and turned out to be a line of rocks. The scale lines on the sonar trace are 15 meters apart. (Copyright Klein Associates, Inc. and the Academy of Applied Science.)



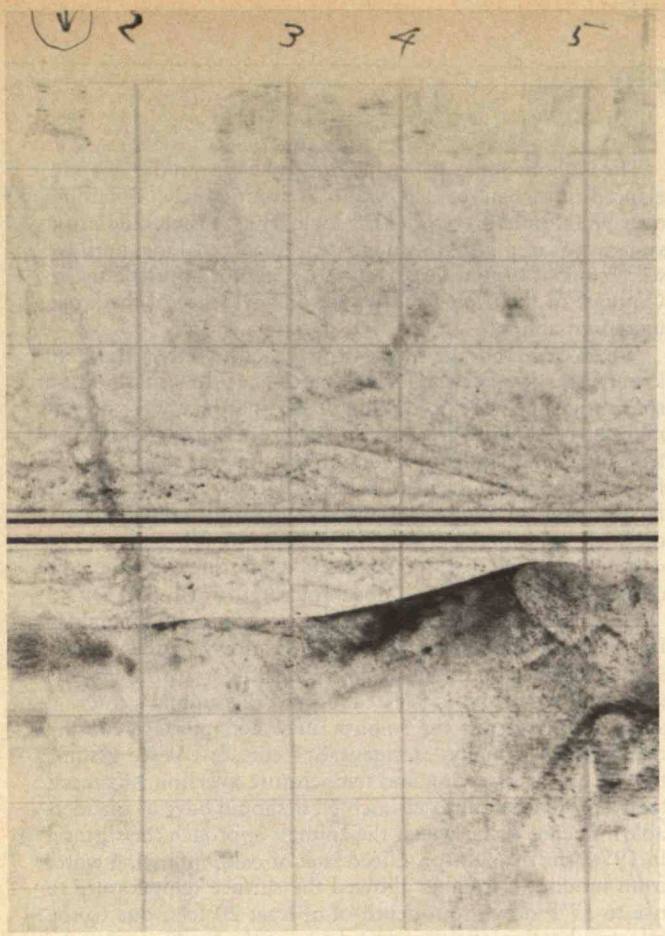
A side scan sonar trace of the steep walls of Loch Ness near Invermoriston. The dark stripes appear to be ridges or projections, and the light areas appear to be undercuts. (Copyright Klein Associates, Inc. and the Academy of Applied Science.)

last ice age had formed the bedrock into a U-shape. Earlier echo soundings had indicated that the steep rock sides of the Loch continued straight down into the sediments, possibly meeting to form a "V." However, geophysicists advised us that the extensions indicated on such echo soundings could be a phenomenon known as "side echoes," which are produced when sound waves bounce off the interface where the steep slope meets the flat bottom. Our sub-bottom profiles revealed that these extensions were, after all, side echoes, because if earlier echo sounders had actually seen bedrock that far below the sediments, they should also have seen the many other sediment layers we picked up with our sonar. One of our profiles is shown on page 47. While our profile indicates that the bedrock is probably U-shaped, we still are not sure that we have penetrated all the sediments, and we recommend further studies with higher-power profiling devices.

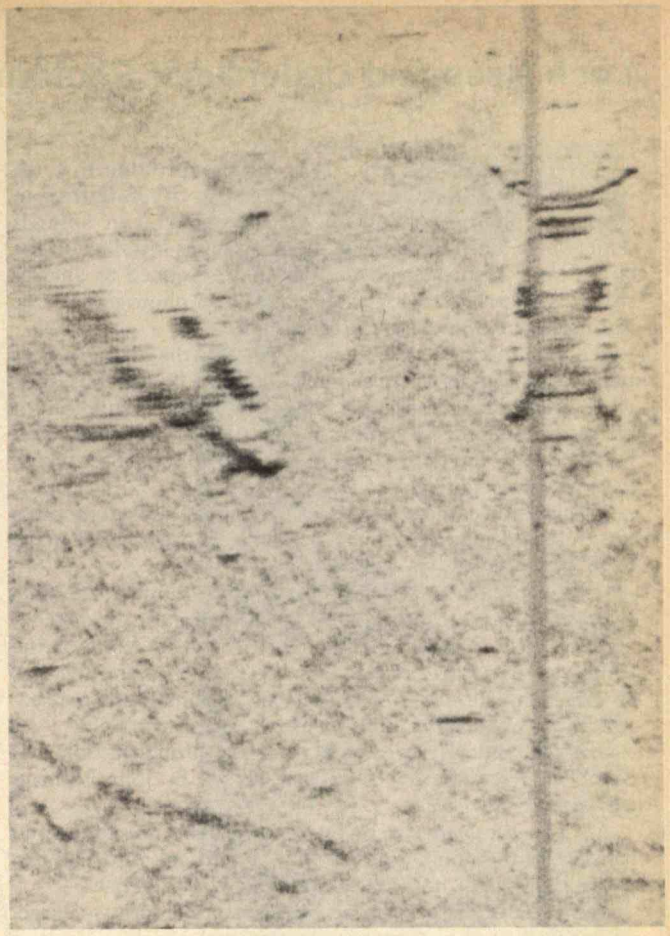
Search for the Carcasses

Our search for bones was to be in the shallow parts of the loch which could easily be investigated by divers. This proved more difficult than we planned, because there are hardly any shallow areas in the loch. In some areas, the sides of the loch slope so steeply that the bow of the boat can be in shallow water while the stern is in deep water! The normal hydrographic charts of the loch are not very detailed, so we set out to find out if a more detailed map existed. Fortunately, we were aided by Dick Raynor and Bill Owen at the Great Glen Exhibition in Fort Augustus, at the southern end of the loch. On the wall of their museum is a lovely map published by Bartholemew of a bathymetric survey of Loch Ness made in 1903 by Sir John Murray using lead lines. The map, made to a scale of 1:21,120 (3 inches to a mile) did not give great detail in shallow areas, but it gave us a lot of ideas. We wound up searching several relatively shallow areas in Urquhart Bay, Dores Bay, Lochend, Borlum Bay and near Cherry Island. Much to our amazement, every area we searched revealed targets of interest.

The first targets appeared on our sonar in Dores Bay, which is in the northern end of the loch (*above left*). Finkelstein observed patterns of objects on the sonar similar to the ones which showed up in the original tests with mammoth bones back in Salem. He dove on one of the formations, and swam around it. It turned out to be rocks which seemed to be in a straight line. While searching the area, Finkelstein was also startled to discover a hump-like formation on the bottom, amidst an area of smooth sand. The formation had a series of regular rib-like ridges on it. The formation turned out to be clay; however, it was later pointed out that the clay could have overlain another more solid structure beneath the silt. Finkelstein took a sample of the structure and gave it to Dr. McGo-



This side scan sonar trace near Cherry Island, at the south end of the loch, revealed an interesting open-sided square structure resting on the bottom (upper left of photo). The lower right-hand side shows echoes of the island structure. (Copyright Klein Associates, Inc. and the Academy of Applied Science.)



One of the most intriguing sonar traces was obtained in Urquhart Bay. The object to the right is almost certainly a wooden sailing barge used to haul freight. The object to the left remains unknown, and should be investigated, say the authors. (Copyright Klein Associates, Inc. and the Academy of Applied Science.)

wan for analysis. Unfortunately, he was unable to return to investigate this intriguing structure.

Next we went on to search Lochend, running a series of survey lines parallel to the northern shore, and some other cross lines. In our lines near the shore, we observed an odd circular formation. George Reid noted that somewhere near here a large steam engine had been in the water. We promptly labeled the odd target "the steam engine" and went along in our survey.

The Mysterious Circles — First Look

As we scanned along the edge of Lochend, we found one target that appeared to be a broken shipwreck. Then we discovered what appeared to be numerous circles and odd circular formations. We were running long days, and we came in each night with piles of records, so it was difficult to put together everything we had found until later. We heard various stories of dredging in Lochend and there were even accounts of explosive mine practice in the area. Our first thought was that the circular patterns were simply texture differences on the bottom created by one of these activities. We went on to survey other parts of the loch, hoping to return to these intriguing circles.

We surveyed the walls of the loch, and we found that the complex geology of ridges and undercuts which we had observed in 1970 ran for miles and miles all along both sides of the loch. The trace on page 48 shows a distinct pattern in the wall which looks like a square "cave" opening with a ridge over it.

Interpreting these records involves a complex geometry since we are looking at a sloping wall rather than the sea floor. We experimented with tipping the transducers to make the normally down-ward looking beam parallel to the slope. This made a different kind of pattern just as difficult to interpret. Unfortunately, we simply need a different kind of sonar system with a very narrow steerable conical beam to investigate these rugged walls in a quantitative fashion.

One of the unusual aspects of working with sonar at Loch Ness is that our sonar seemed to get unusually long ranges in this water. We discovered the phenomenon in 1970, and found the same thing in our 1976 experiments. Our 100 kHz side scan normally obtains average ranges of 200 to 300 meters on either side. In the loch, we were able to obtain ranges of up to 855 meters in some places. In fact, at times we were able to sail down the center and pick up both sides at once. It is known that Loch Ness has a low content of magnesium sulphate, a large molecule which is said to be a main factor in the attenuation of underwater sound.

We also found that this year in the loch we did not pick up the deep schools of fish which we had found years earlier. We speculated that the lack of rain (which is most unusual for the British Isles) may have been a cause.

Loch Ness and Underwater Photography

The photographic segment of the 1976 expedition to Loch Ness included a number of techniques never before tried in efforts to photograph the loch's large, unknown animals underwater. Each of the new camera systems installed on the large frame suspended in the loch was designed to answer specific deficiencies recognized in the 1975 photographs (*see* Technology Review, *March/April, p. 25*):

— To give more precise measurements of the animal's size, two 35-mm. underwater cameras, donated by Benthos, Inc., were arranged stereoscopically to allow triangulation of measurements on any photographs. These cameras used Kodak 2485 Film (ASA 2000) and had 16-mm. lenses which gave a wide-angle field of view.

— A television camera allowed a human operator to monitor the area in front of the cameras and trigger the other cameras at the proper time via a control box on shore.

— A videotape recorder, donated by Blonder Tongue Laboratories, attached to the television monitor produced a moving picture record of whatever swam in front of the cameras. The recorder could be set to record either at regular speed, or at a slower, time-lapse speed of one frame per second to allow longer taping times between rewinding.

— Instant pictures were made possible through a Polaroid SX-70 camera, adapted to underwater use by John Lothrop of Polaroid Corp.

Also on the frame were two strobe lights for the stereo cameras (150 and 50 watt-second) and a bank of flashbulbs in an underwater housing for the Polaroid camera.

Because the Loch Ness animals are apparently so large, and the range of photography in the murky loch so short, a major problem is how to obtain on a single frame an image of the animal's entire body. In 1972 and 1975 we had obtained "pieces" of an animal in our underwater photographs, but some sort of overall concept of the animal was needed in which to fit these pieces. We decided to capitalize on the fact that it was possible to photograph large areas in silhouette by placing a camera in the loch aimed upward, and using the sun as a light source. Vernon E. (Bill) MacRoberts of Professor Edgerton's laboratory and John Lothrop built for us a "silhouette" camera, which was a 35-mm. elapsed-time camera in a cylindrical waterproof housing. This camera would hang in the loch separate from the other systems taking a picture about every five seconds. It would be deployed only during sunlight hours and only if there was enough "activity" around the research area to warrant the effort.

Our third camera system consisted of the 16-mm. elapsed-time camera which had obtained the 1972 "flipper" photograph and 1975 pictures of what we believe to be a large animal. This year the strobe light was powered by a line to shore, rather than by batteries, so the unit could be more powerful and easier to service. The camera was loaded with high-speed Ektachrome film (ASA 160). We decided to aim the TV/stereo/Polaroid camera frame at the 16-mm. camera, because in 1975 the animal seemed to be attracted to it, for we had evidence that before or after several pictures of unknown surfaces or objects, the camera was knocked upward, photographing the bottom of the boat from which it was hung. Thus, we arrived at the arrangement of cameras shown in the drawing to the right.

During the 1976 expedition John Lothrop assembled a portable camera system consisting of a 35-mm. camera and 50 watt-second strobe, all battery powered. This portable unit allowed us to investigate other areas in the loch, either by making the unit sonar-activated or allowing it to operate in an elapsed-time mode, taking pictures every 15 seconds.

Throughout June, 1976, and into July, we ran the 16-mm., elapsed-time bait camera almost continuously, obtaining over 98,000 pictures under the loch. The TV/stereo/Polaroid system was monitored through a large part of June, until we were convinced that large animals were not approaching it. On none of the frames did we see any evidence of the large, unknown animals.

We theorize that the severe drought in the British Isles had lowered the level of the loch so much that the usual salmon spawning runs were not taking place, and there were no salmon in the shallow areas of the loch to bring the animal up from its usual depths to feed. Support for this theory comes from the poor fishing season being had by anglers, and the fact that out of almost 100,000 photographs taken beneath the loch, we obtained only 33 pictures of fish and eels. In contrast, one roll of 2,000 frames taken during the same time of year in 1975 showed a dozen pictures of fish and eels.

One interesting theory holds that the unknown animals in Loch Ness dislike higher temperatures and avoid the warmer surface of the water. (According to this theory, surfacing occurs only when the loch is calm, and the animal's internal sonar cannot detect the smooth air-water interface causing them to occasionally "accidentally" surface.) If we assume this theory of surfacing and temperature aversion is correct, the water temperatures at Loch Ness should have a considerable influence on how near the animals approach the surface. In 1976, the drought-produced lack of cold, inflowing water from mountain streams allowed the surface temperature to rise to 57°F down to a depth of at least 20 feet, due to the effective heating of the surface layer of the brown waters by the sun. This was far above the usual temperature of 42°F. Such warm surface layers may have driven the animals down into the cooler depths of the loch.

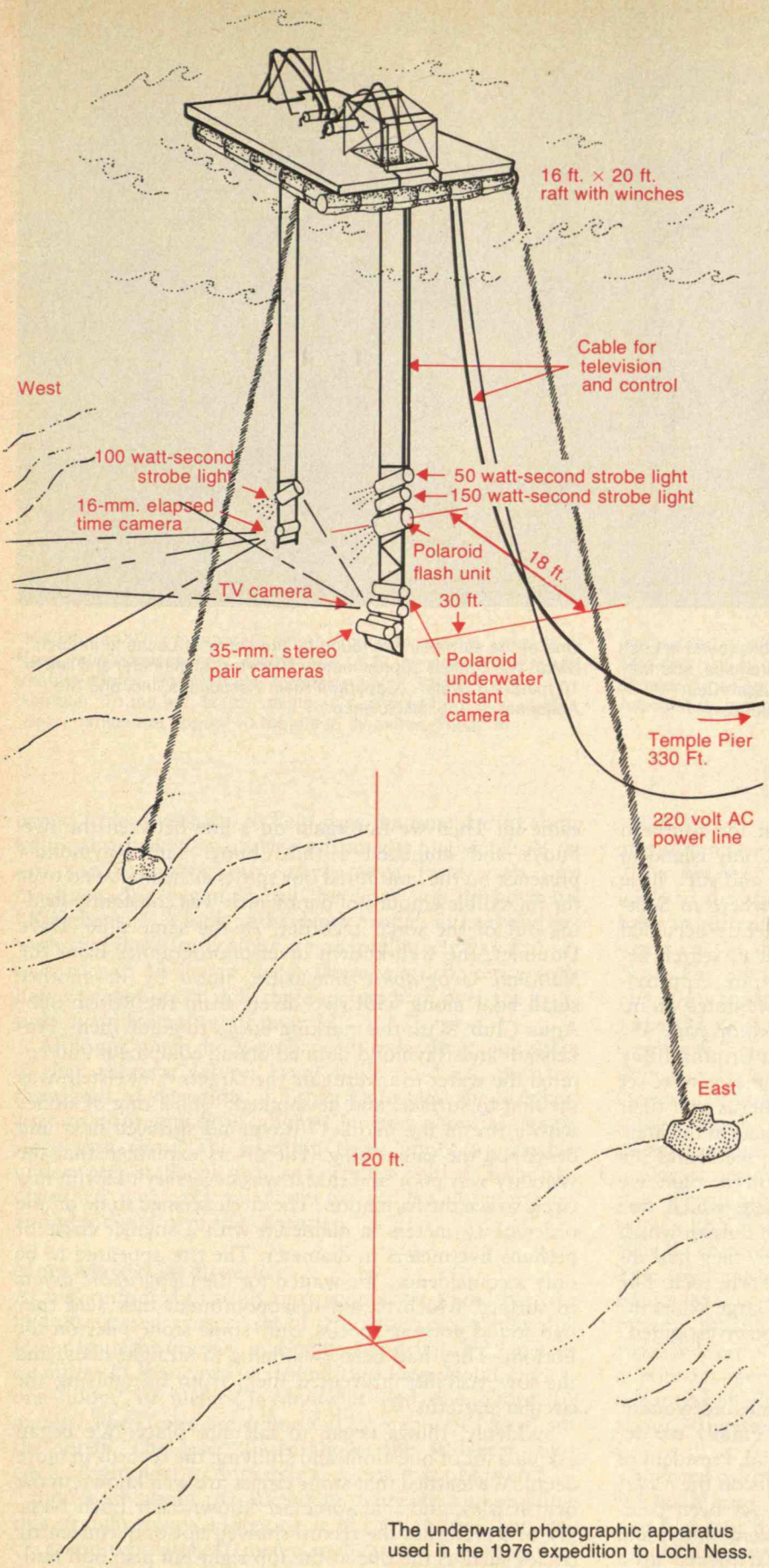
Although we did not obtain any photographic evidence in 1976, we did have a chance to investigate further the possibilities for underwater photography in the loch, and we remain convinced that underwater photography is the only logical way to aim future expeditions.

In fact, the loch is not as forbidding a place photographically as we had believed. Calibration tests showed that the television camera could detect certain objects as far as 25 feet away, and we are convinced that it is quite possible to obtain still photographs as far as 40 feet away.

For future expeditions the Academy plans to increase the photographic range and improve lighting by installing more strobe lights on the research raft we are now using. These "slave" strobes will have photoelectric cells attached which will be triggered by the light from the main strobe light, attached to the cameras.

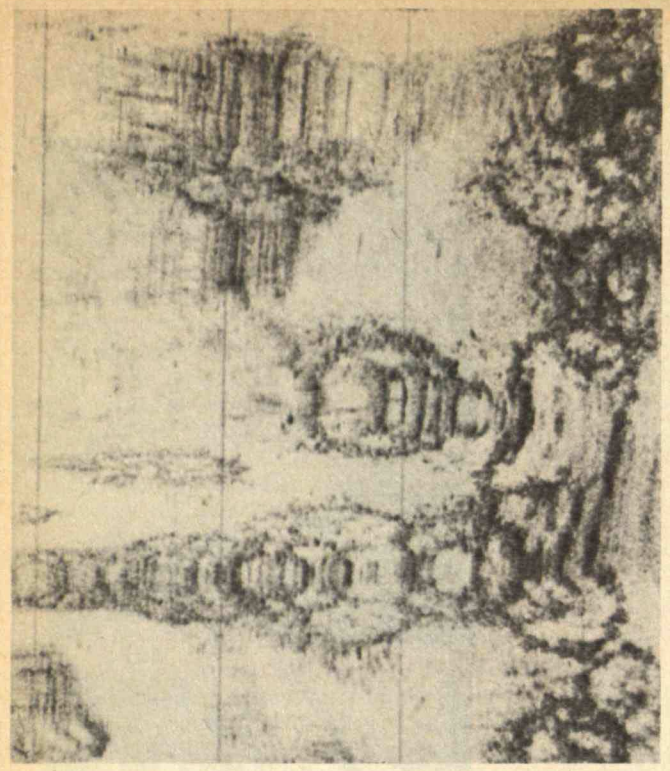
Rather than rely solely on human operators manning a monitoring station, we plan to resort to sonar-activated cameras, in which a sonar transducer attached to the camera will monitor the area in front of the camera. A computer attached to the sonar device is "gated" so that only objects over a certain size moving into the beam will trigger the camera to begin taking an elapsed-time picture once every five seconds as long as the object remains in the field of view. If it turns out in future expeditions that the sonar-activated cameras are seeing considerable action, we will revert to the TV/stereo/Polaroid type camera systems monitored by human operators.

We also plan to continue other experiments to obtain further sonar records of the animals' movements and perhaps sound recordings. — *Charles W. Wyckoff, Applied Photo Sciences, Inc.*

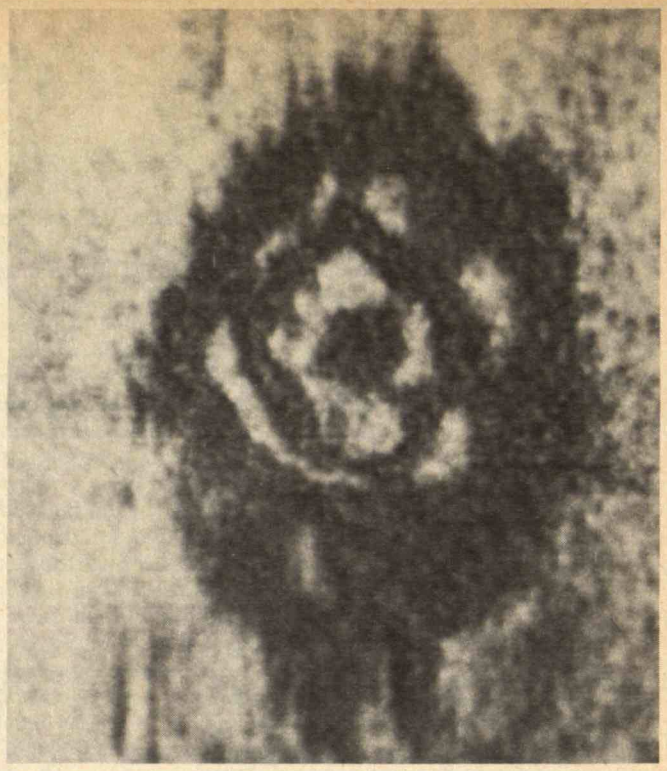


The underwater photographic apparatus used in the 1976 expedition to Loch Ness.

Charles Wyckoff loads film into one of the stereo 35-mm. cameras, in preparation for its first "splashdown" in Loch Ness. The stereo cameras would allow more precise measurements of any object photographed underwater, for sizes could be calculated using triangulation. (Photo: Dennis Meredith)



"Kleinhenge I" — a series of stone circle formations found in Loch Ness. One of the formations consists of multiple circles, and the total formation is at least 75 meters long. (Copyright Klein Associates, Inc. and the Academy of Applied Science.)



One of the stone circles found by the sonar at Lochend in Loch Ness. The circle is approximately 10 meters in diameter and lies in 10 meters of water. (Copyright Klein Associates, Inc. and the Academy of Applied Science.)

We continued on to Cherry Island near the southern end of the loch. This tiny structure is the only island in Loch Ness. It is known to be man-made, and such little islands, called crannogs, are known elsewhere in Scotland. At one time, the islands were apparently occupied by small forts. The area was very difficult to search because of the very rapidly changing bottom. Approximately 100 meters away from the island we noted an interesting open-sided square structure as seen on page 49.

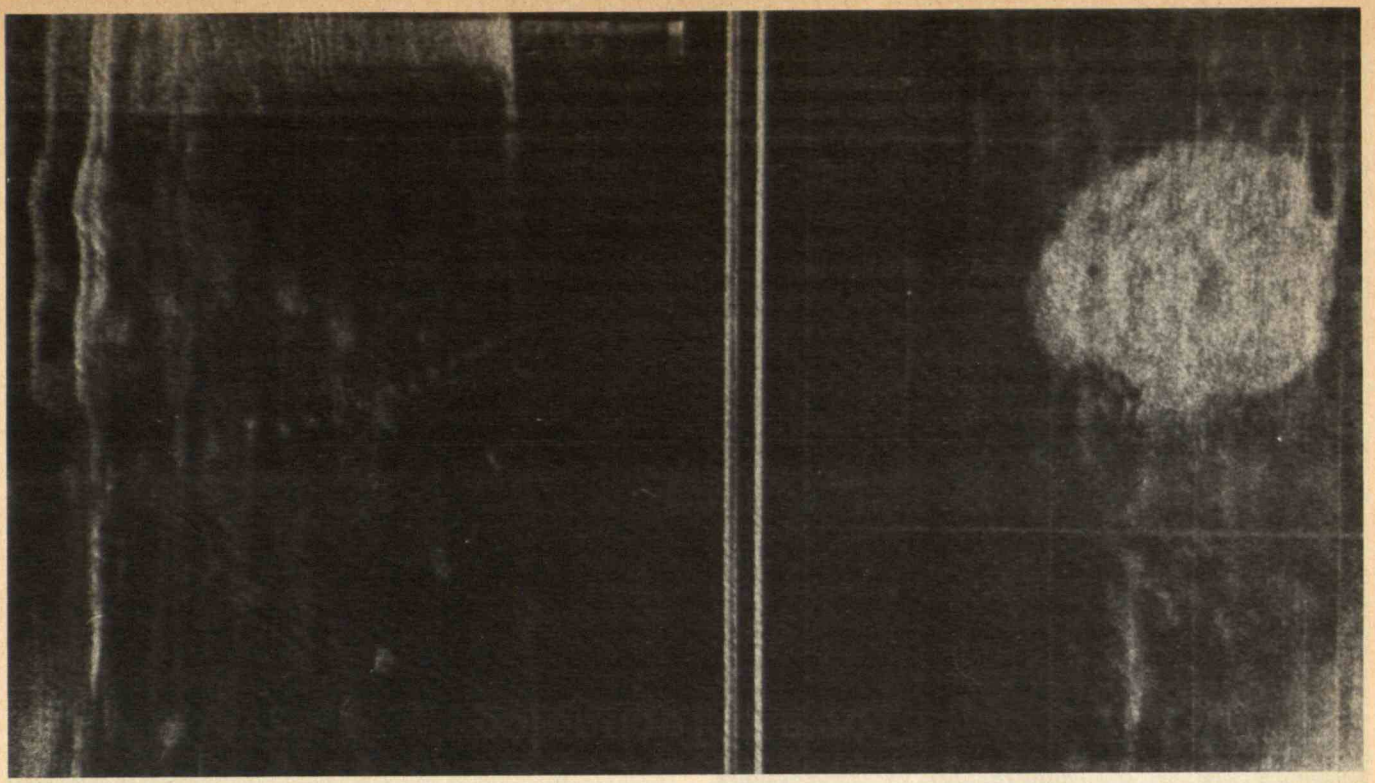
Next, we decided to take a quick run in Urquhart Bay near Temple Pier where the underwater cameras were set up. We were able to see the pier, the cameras and their rigging, and the moorings of the various boats in the area. Approximately 100 meters from the pier, we found the two targets shown on page 49. The target on the right, we feel certain, is an old wooden sailing barge which was well known to the Loch Ness Investigation Bureau which studied the loch in previous years. In fact, they had inspected it several years ago while we were at the loch. The target next to it . . . another shipwreck? A large skeleton? We don't know, but it certainly needs to be investigated.

The Circles Discovered!

As we proceeded with the work, we continued to wonder about the circle formations at Lochend. Finally we decided to take time to find out. Sam Raymond, President of Benthos, Inc. of Falmouth, Mass., joined us on the *Malaran*. Since our navigation plots had not yet been completed, we brought along the sonar and several buoys and began to run in the area. When the sonar picked up a clear circle we launched a buoy. We turned in the opposite direction and launched another buoy when the target came in. Then we ran again on a line between the two buoys and launched a third buoy. Sam Raymond's presence on the boat lifted our spirits as he marveled over the incredible amount of data which was constantly feeding out of the sonar recorder. At the same time, Dave Doubilet, the well-known diver-photographer from the *National Geographic* magazine, stood by in another small boat along with two divers from the British Sub-Aqua Club. With the marking buoys to guide them, Finkelstein and Raymond donned diving equipment and entered the water to investigate the targets. Finkelstein was the first to surface, and he shouted, "It's a ring of stones with a tire in the middle!" Raymond surfaced next and described the same thing. The divers explained that the visibility was poor and that it was necessary to swim in a circle to see the formation. The circle seemed to be on the order of 10 meters in diameter, with a smaller circle of perhaps five meters in diameter. The tire appeared to be only a coincidence. We waited for the *Geographic* divers to surface. Much to our disappointment they said they had found nothing special, only some stone piles on the bottom. They had been swimming in straight lines, and the low visibility prevented them from recognizing the circular patterns.

Suddenly, things began to fall into place. We began asking a lot of questions and studying the records in more detail. We learned that stone circles are well known in the British Isles, and that some are known near Loch Ness. We observed that the record showed not only concentric circles such as the one at the top right but also odd multiple circle formations such as the ones at top left.

One of the traditions of our sonar survey business is to



"Kleinhenge II" is a separate set of circular formations in Loch Ness, much deeper than "Kleinhenge I." At the right of the sonar trace is a large, solid circular formation about 30 meters in diameter. To the left, faintly visible, is a straight formation of 20 "dots," which are about two meters in diameter. These are surrounded by a larger 50-meter circle of similar "dots." The image was reversed to give better resolution, so that the sonar contacts showed up as light areas on a dark background. (Copyright Klein Associates, Inc. and the Academy of Applied Science.)

invent little diversions to help pass the time during long hours of survey. One of these pastimes is to give names to our sonar targets, our survey areas and even our machines. We began to call the circle area in Lochend "Kleinhenge." A look at the depth profiles in Lochend reveals that these formations are on a relatively flat area on the order of 10 meters deep. There is a definite mound, however, approximately three meters high over the multiple circle formation of page 52.

Although much more study needs to be done, our guess is that these structures were built on land, perhaps thousands of years ago, and that the level of the loch has risen to its present level (about 17 meters above sea level) since that time. The exciting thing about a possible underwater archaeological site is that it is likely to be undisturbed, whereas similar sites on land have been moved and plundered over the centuries.

More Mysterious Patterns

As we continued to study our records, we found that we had discovered *another* set of structures, completely different from the first set, in even deeper water of 25 meters or more. In this case, we found two large, solid circles, one about 30 meters in diameter and one about 16 meters. The circles are connected by a row of "dots" on the sonar. The trace above shows the 30-meter solid circle. Right next to this circle is a long row of around 20 "dots" each about two meters in diameter. Surrounding this straight row is a large circle of similar dots. This circle is approximately 50 meters in diameter. A giant underwater clock? A calendar? Or perhaps only a strange coincidence. Only time and detailed investigation will tell.

We appear to have discovered two relatively flat areas at different levels underwater, which we now refer to as "Kleinhenge I" and "Kleinhenge II." A look at their levels leads to the speculation that the two sets of rings were built in different eras, and both were perhaps built on what was, at their respective times, the "beach" at Loch Ness. The discovery could, of course, have dramatic implications regarding the possible water levels in the loch since the glacial period about 12,000 years ago during which the loch was buried under thousands of feet of ice. Our discoveries may give evidence that the loch and the Great Glen were more intimately connected to the sea, a subject which often comes up when the famous monster (a sea creature?) is discussed.

One of our most intriguing discoveries on the loch bottom was an airplane! The plane (*see page 55*) turned out to be a PBY Flying Boat which went down during World War II. The crew of four escaped when the plane ditched. The American-built plane was operated by the Royal Air Force. It had a wingspan of 35 meters and a length of 32 meters. Two large 1,050 horsepower Pratt and Whitney engines were mounted on the wings. The plane had a maximum speed of 179 miles per hour. Judging by the sonar record, the plane appears to be reasonably intact in about 30 meters of water.

The Final Surprise

We made some of our last runs with the side scan in Borlum Bay near the Abbey in Fort Augustus. As is often the situation in our type of work, we made one of our most intriguing finds just as we were about to wind up our survey. In approximately 100 meters of water, we picked up

A Sonar Watch Pays Off

Although the photographic portion of the 1976 Academy of Applied Science/*New York Times* expedition to Loch Ness failed to capture photographs of large animals under the loch, a number of intriguing sonar contacts were obtained of large, moving, underwater objects. These contacts confirmed that there were subjects to be photographed in the loch, but not within photographic range.

The sonar apparatus was set up underwater off Temple Pier and aimed out into the loch so that it "watched" the underwater camera rig. At first we used a side-scan sonar fish, with one of its two fan-shaped vertical beams aimed outward to illuminate the cameras. However, on June 30, we developed a more sophisticated system. We mounted the sonar towfish on a metal stand which would hold it about 2½ feet off the bottom, and placed the fish about 10 meters off Temple Pier. We also mounted on this stand the sonar transducer from the other side of the sonar fish, so that the beam would be a horizontal fan. This combination of beams gave an indication of both the vertical and the lateral location of objects moving in the beam.

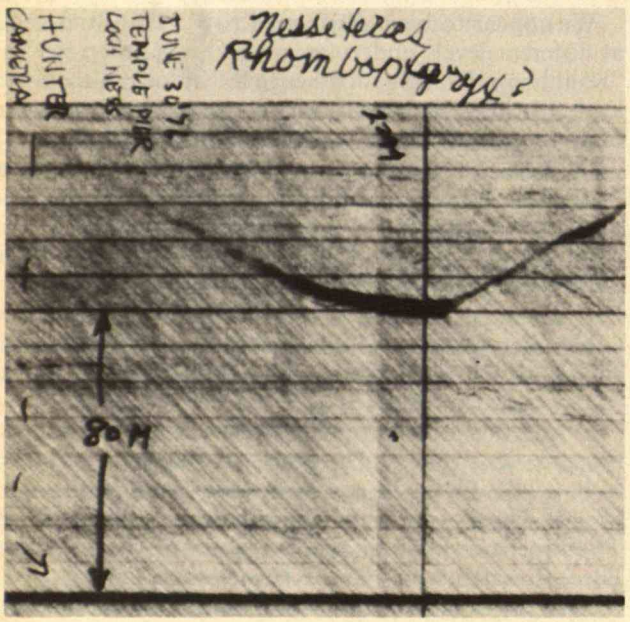
The vertical and horizontal sound beams were then centered on the underwater camera rigs. The sonar beams were 55 meters from the cameras, and the sonar rig had a range of 200 meters. We monitored the system as much as was feasible during the period of June 23 to July 5, and we obtained numerous fairly large targets. Unfortunately all of the targets were at considerable distance from the underwater cameras.

The two most important sonar traces came on June 30 and July 1, 1976. The June 30 contact, obtained while Helen Wyckoff was on watch, occurred at 22:44 hours. The sonar trace (*see below left*) shows an object coming in at a distance of 180 meters from the sonar (120 meters from the camera). After about a minute of movement inward, the object slowed and stopped, presenting a target width of three meters. After about one minute of rest, 80 meters from the cameras, the object departed with about the same velocity, but with a slight hesitation after about one minute of movement. Also on this record can be seen two small signals, which could be reflections from disturbed fish.

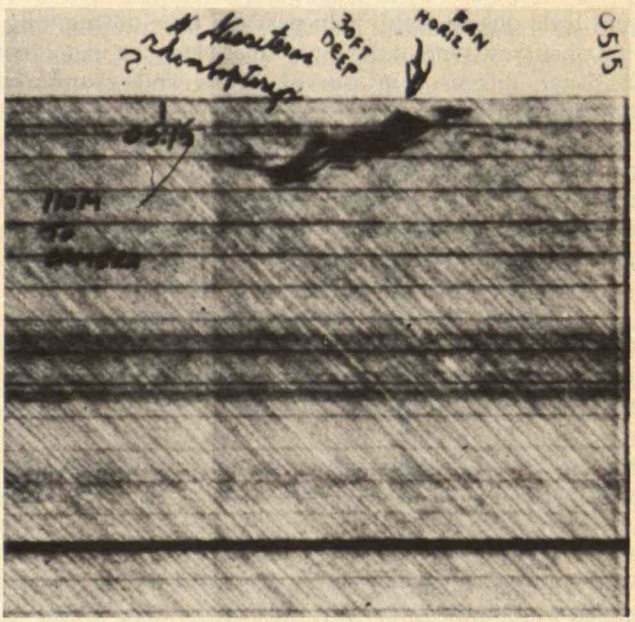
The second important sonar contact occurred on July 1, 1976, about 05:00 hours while Charles Wyckoff was on watch. This sonar contact (*see below right*) had a target width of about ten meters. This contact was interesting because of the filamentous nature of the traces, which indicated a number of reflecting surfaces. Also, note the small trace that could be caused by a fish that had been alarmed.

On July 5, a large research barge was installed to support the cameras, and although monitoring continued, no further contacts were observed. It is not certain whether the barge had anything to do with the scarcity of targets. These 1976 contacts were only the latest of many past sonar contacts with large moving objects under the loch, including contacts by Martin Klein in 1970 and Robert Rines in 1972. Our contacts confirm that there are large, presumably animate, objects under the loch that should be further investigated. The 1976 results also show that sonar is an excellent tool to provide camera operators with warning of approaching photographic subjects and to study the movements of underwater creatures to decide camera placement — *Harold E. Edgerton, M.I.T.*

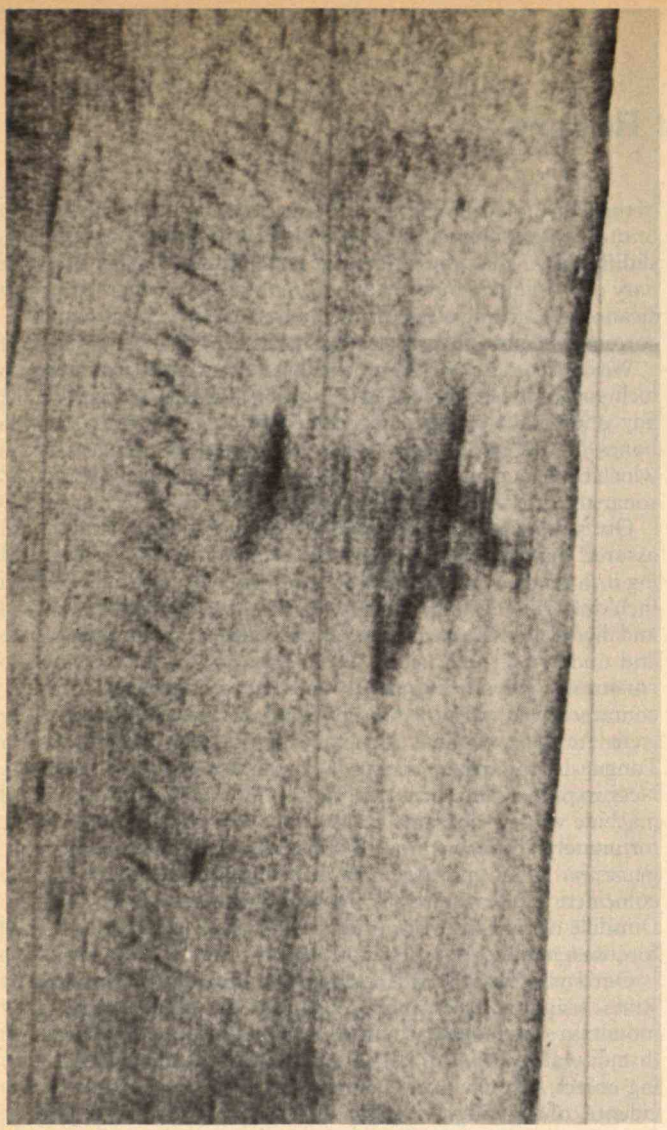
(The side scan sonar used in the stationary mode sonar watch was an EG&G Model 259.)



On June 30, 1976, a large underwater object moved into the expedition's sonar beam, approached within 80 meters of the underwater cameras, paused for a few minutes, and then departed. The time scale on the sonar trace reads from left to right, and each horizontal line represents ten meters of distance from the sonar. Note the small traces which could represent fish in the beam. The horizontal line at the bottom represents the trace of the permanently anchored cameras.



On July 1, 1976, a large object again intruded on the sonar beam, giving a target width of ten meters. This object gave a parallel-trace type of contact. The thick, horizontal line at the bottom represents the trace from the underwater cameras. Each horizontal distance mark represents ten meters. Note the small trace to the right of the larger one which could represent a fish moving in the beam. (Both photos copyright Academy of Applied Science.)



Sonar record of a PBY aircraft discovered on the 1976 survey lying in 34 meters of water in Loch Ness. This plane was an American-made "flying boat" operated by the R.A.F. It went down during World War II, and its crew of four escaped. (Copyright Klein Associates, Inc. and the Academy of Applied Science.)

The object in this sonar trace was nicknamed "The Average Plesiosaur," after the prehistoric reptile that has been one candidate for the identity of the Loch Ness monster. The object, about 10 meters long, was detected in about 100 meters of water off Fort Augustus. (Copyright Klein Associates, Inc. and the Academy of Applied Science.)

the target shown above right. The target has a carcass-like shape with a long neck-like projection, and the whole thing appears to be about 10 meters long. It does not look like any of the other targets which we picked up in the loch. Of course, it would be wild speculation to make any assumptions about this target without further investigation. An underwater television or a small submersible would probably be needed for identification at this depth. We named this target "The Average Plesiosaur" to tease our paleontologist friends. It will be interesting to find if the target is still there when we next go to look for it.

We have obviously made many interesting discoveries with our side scan sonar and sub-bottom profiler in Loch Ness. Our work was only a beginning, but we feel that a detailed full-scale exploration survey would be fully justified. Our records and maps are, of course, available for further study by archaeologists or any others interested in further investigation of our finds. *(The sonar system used in Loch Ness was a Klein Model 430 HYDROSCAN Side Scan Sonar — Sub-Bottom Profiler System with a Model 431 Three-Channel Klein Recorder. The system features Hands-Off Tuning® with Texture Enhancement.™)*

Suggested Readings — Side Scan Sonar

Bass, G. F., "New Tools for Undersea Archeology," *National Geographic,* Volume 134, No. 3, September, 1968.

Clay, C. S., Ess, J., and Weisman, I., "Lateral Echo Sounding of the Ocean Bottom on the Continental Rise," *Journal of Geophysical Research,* Vol. 69, No. 18, September 15, 1964.

Cole, F. W., *A Familiarization with Lateral or Side Scanning Sonars,* Hudson Laboratories, Dobbs Ferry, New York, Technical Report No. 159, July, 1968.

Klein, M. and Edgerton, H. E., "Sonar — A Modern Technique for Ocean Exploitation," *IEEE Spectrum,* June, 1968.

Klein, M., "Side Scan Sonar," *Undersea Technology,* April, 1967.

Klein, M., "Sonar Search at Loch Ness," *Preprints of the Seventh Annual Conference,* Marine Technology Society, Washington, D.C., August 16-18, 1971.

Klein, M. and Jolly, J., "The Use of Side Scan Sonar to Identify Sea-

The 1976 Expedition: Links With Past Results

When we obtained the June 30 and July 1, 1976, sonar traces of large objects moving underwater in Loch Ness, it was a personal thrill to see that Charles Wyckoff had pencilled in beside the targets the words *Nessiteras rhombopteryx*. This was the scientific name for the Loch Ness animals, which we introduced with Sir Peter Scott (*Nature*, Vol. 258, December 11, 1975, p. 466) to secure conservation protection for them.

What Charlie Wyckoff had noted about the trace, as had we all, was that there was a definite similarity between the multiple parallel traces of 1976 and the parallel sonar traces obtained with an entirely different machine on August 9, 1972. (The 1972 traces, showing two large objects under the loch, were obtained with the sonar operated in the same stationary mode. They appeared at the same time our underwater elapsed-time camera obtained the two 1972 flipper photographs and a third photograph suggestive of two large bodies in the frame.)

Especially fascinating was that in both the 1972 and the July 1, 1976, targets we found substantially the same number of parallel traces, with substantially the same spacing and extending over approximately the same 10 meters of target width.

In the 1972 sonar trace (*see below*) the parallel traces maintained the same spacing throughout the period of the record, until the traces changed into a single, thick trace. One might speculate that these changes into a single, thick trace represented another aspect of the same object as it turned. (We think "side view.")

Another interesting coincidence is that the thick, single trace of the second object in the 1972 trace had the same approximately three-meter target width as the June 30, 1976, target. All this, despite the large differences between the 1972 sonar apparatus — a modified Raytheon DE 725C depth-type sonar — which had a frequency about twice that of the EG&G side scan sonar used in the 1976 traces.

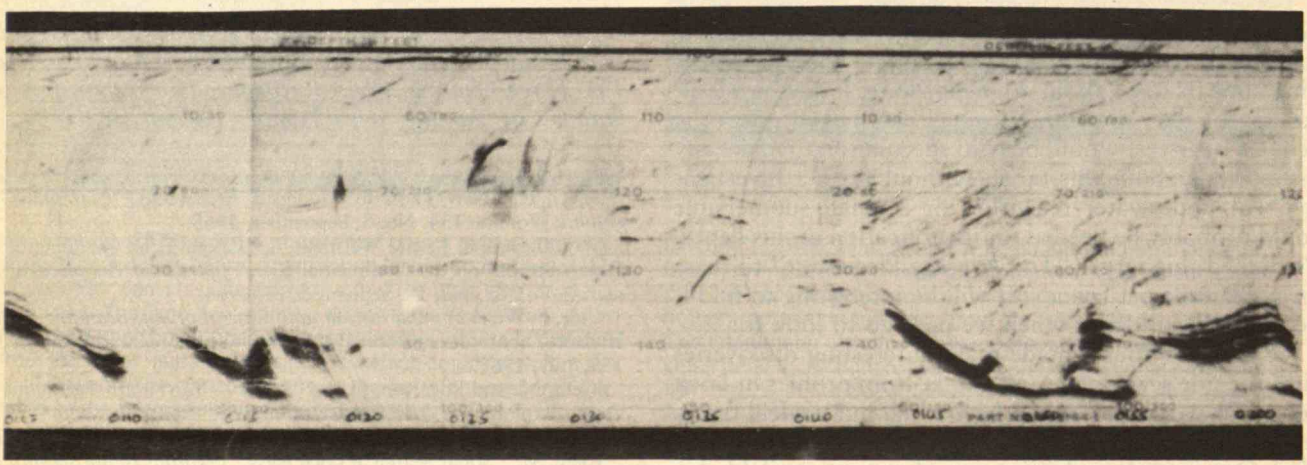
Just as our photographic techniques at Loch Ness have continued to improve, so has our use of sonar become more sophisticated — we hope with benefit to other areas of underwater exploration. For instance, in the 1976 expedition, working with Christopher McGowan of the Royal Ontario Museum, we evolved a technique to enable very accurate dredging along the interface between the steep side-walls of the loch and its flat bottom. We theorize that animal bones or other interesting objects might lodge at this interface, after sliding down the precipitous sides. We found that an ordinary depth-finder could readily be monitored for the first indication of a rising slope from the bottom. The pilot could correct his course to keep the dredge in the area of interest.

We carried out preliminary dredging along a portion of the loch south of Urquhart Castle, without having to resort to any above-the-surface navigation. Although we found no bones in this sampling, we recovered extensive lengths of winch cable and other debris, and perhaps developed a useful sonar tool for further dredging operations.

Our studies at Loch Ness will resume as soon as we can be assured that spawning salmon and sea trout will be migrating into the loch in considerable numbers. These studies will include mobile forays into other bays of the loch with sonar and hydrophone monitoring of suspended strobe cameras and underwater television. We undertook several such excursions in July, 1976, and in one, had a fascinating sonar contact. It was early one morning, and on board the *Malaran* were Academy board chairman Ike Blonder of Blonder Tongue Laboratories, his son Greg, and well-known Loch Ness explorer Tim Dinsdale. While monitoring the sonar machine we saw a sizable object move into the beam — unfortunately above the level of our underwater camera rig — pause for a few minutes, and then disappear. The contact coincided with a startling hydrophone detection by Tim Dinsdale of chirp-like or rattle-like sounds, which ceased before we could begin tape-recording.

Our surface-watch was carried out principally by Carol Rines using a Questar-telescope-camera system from a mountain overlooking the loch. She noted only two large, distant wake disturbances, as from a large, submerged moving object, throughout the summer, which is a very low incidence of sightings for this station, compared with past years.

Another research project, by Professor George Newton of M.I.T., aimed at determining whether infrared scanning of the loch surface might be able to detect tiny temperature differences between surfacing animals and the surrounding waters. Dr. Newton used a sensitive infrared scanner loaned by Magnavox Government and Industrial Electronics, and found he could detect fractional-degree variations at ranges



of up to two miles. Such a system could monitor surfacings of large creatures more effectively than visible-light-based schemes, since it can function under adverse weather conditions and at night.

As usual, the expedition to Loch Ness was a volunteer effort, and many individuals and companies gave of their time, effort and products. From *Technology Review* came Dennis Meredith, who acted as press officer and aided with the operations. From the *New York Times* came chief science writer John Noble Wilford and London correspondent Robert Semple, and from N.B.C. came film unit manager Nick O'Gorman and his colleagues. Academy staff members Howard Curtis and Robert Needleman gave logistic support for the complex undertaking, and we were fortunate in having the local aid of Gordon MacKintosh, who acted as a liason with Scottish authorities. And, of course, the business of ferrying 2,000 pounds of equipment was handled with dispatch by British Airways.

For the present, we are continuing automatic photographic surveillance in Urquhart Bay, using our sonar-triggered underwater camera system, set to activate upon the approach of a large underwater object. These systems are being maintained by two Scottish associates, Alex Menzies and Tony Gerlings.

We hope to resume surveys this spring with television, camera, and divers to investigate the interesting sonar targets obtained in the Klein/McGowan/Finkelstein scans of the loch. We will receive aid in these surveys from John D. Mills of Underwater Instrumentation Co., Weybridge, England, and Aberdeen, Scotland, and from Robert Helmreich, University of Texas. Dr. Helmreich is a psychologist who visited the expedition to study the human interactions of the expedition members, as part of a study for N.A.S.A. on choosing crews for the Space Shuttle. We discovered that Dr. Helmreich was an experienced diver and persuaded him to use his expertise to help us photograph "Kleinhenge" and other underwater targets.

It was a minor miracle, keeping a host of scientists, each normally accustomed to leading his own project, working harmoniously, but, although we didn't contact the animals in the loch as closely as we would have liked, we have certainly proven our equipment. — *Robert H. Rines, Academy of Applied Science*

The August 9, 1972, sonar contacts with large, moving, underwater objects closely resembled the 1976 contacts (*see page 54*). The July 1, 1976, contact consisted of a number of parallel traces, resembling the parallel-trace objects in the 1972 contact. The other 1976 contact consisted of a smaller, thick, solid trace, also like one of the 1972 contacts. The trace at left shows two separate encounters with the objects, one beginning around 1:00 a.m., and one around 1:45 a.m. During the second contact, the "flipper" pictures were obtained by the elapsed-time underwater camera. The small traces on the record are almost certainly fish. (Copyright Academy of Applied Science)

Floor Characteristics," *Proceedings of the International Symposium on the Engineering Properties of Sea-Floor Soils and Their Geophysical Identification*, Seattle, Washington, July 25, 1971.

Klein, M., Van Koevering, B. D., and Michelsen, F. C., "A New Depressor and Recovery Method for Undersea Towed Vehicles," *Preprints of the Eighth Annual Conference*, Marine Technology Society, 1972.

Krotser, D. and Klein, M., "Side-Scan Sonar; Selective Textural Enhancement," *Oceans '76*, Marine Technology Society — IEEE Conference, Washington, D.C. September, 1976.

Sargent, G. E. G., "Application of Acoustics and Ultrasonics to Marine Geology," *Ultrasonics*, January, 1968.

Sargent, G.E.G., "Profiling and Sonar Techniques for Underwater Pipeline Surveying," *Hydrospace*, December, 1968.

Tucker, M. J., "Sideways Looking Sonar for Marine Geology," *Geo-Marine Technology*, October, 1966.

Yules, J. A. and Edgerton, H. E., "Bottom Sonar Search Techniques," *Undersea Technology*, November, 1964.

Suggested Readings — Stone Circles and Archaeology of Scotland

Burl, Aubrey, *The Stone Circles of the British Isles*, Yale University Press, New Haven, 1976.

Edgerton, Harold E., "Stonehenge — New Light on an Old Riddle,'" *National Geographic*, Vol. 117, No. 6, June, 1960, pp. 846-866.

Hadingham, Evan, *Circles and Standing Stones*, Heinemann, London, 1975.

Hawkins, Gerald, *Stonehenge Decoded*, Dell Publishing Co., Inc., New York, 1965.

Henshall, Audrey Shore, *The Chambered Tombs of Scotland*, Vols. 1 and 2, Edinburgh University Press, Edinburgh, 1963.

Inverness Field Club, Paul Harris, *The Hub of the Highlands*, The Albyn Press, Edinburgh, 1975.

MacKie, Euan W., *Scotland: An Archaeological Guide*, Faber and Farber Limited, London, 1975.

Piggott, Stuart, *The Druids*, Penguin Books, Harmondsworth, 1974 (First published by Thames and Hudson, 1968).

Thom, A., *Megalithic Sites in Britain*, Oxford University Press, London, 1967.

Martin Klein received his S.B. in electrical engineering from M.I.T. in 1962 and has done graduate work in physical oceanography at Northeastern University. He is currently president and founder of Klein Associates, Inc. of Salem, New Hampshire. Before forming Klein Associates he was Program Manager for Sonar Systems at EG&G International, Inc., where he was responsible for the design, development and field operation of the EG&G Mark 1 Side Scan Sonar System. He was also responsible for the design and installation of the first side scan sonar system on the bathyscape *Trieste*, and has worked with numerous other deep-diving research submersibles. He also has extensive ocean survey and exploration experience in the waters of North America, Europe and Asia. **Charles Finkelstein** is a design and development engineer with Klein Associates, Inc. He is working toward his S.B. in electrical engineering at M.I.T. He has participated in several projects in developing undersea research instruments, and is an expert scuba diver.

Color Reprints Available

A full-color reprint of *Technology Review*'s exclusive March/April, 1976, article on the Loch Ness evidence is available for $1.00 from "Ness," *Technology Review*, E-19-430, M.I.T., Cambridge, Mass. 02139. The article, by Robert H. Rines, Charles W. Wyckoff, Harold E. Edgerton, and Martin Klein, contains a full analysis of the controversial 1972 and 1975 photographs and sonar evidence concerning the Loch Ness monster.

Roy Kaplow
Professor of Materials Science
and Engineering
M.I.T.

Engineering System Homilies My Grandmother Never Told Me

Actually, I can't recall for sure that either one of my grandmothers told me any homilies at all. So the title is just a joke of sorts. On the other hand, it contains a point about which I am quite serious: the ideas which I'd like to discuss *might well* have been part of a sermon to a grandson on how he should properly conduct himself professionally, by an elderly and not highly educated lady. That is, this paper deals with what is often called "common sense" — even though the sense that I refer to may not, after all, be altogether common. The reader may end up feeling that I haven't said anything that wasn't rather obvious. If that turns out to be the case, I will nonetheless be altogether pleased if I only *remind* you of some things that will help you to keep your mind on the "forest *and* the trees" simultaneously.

For the systems engineer, here are nine homilies — brief exhortations on points which should be simple but seem to be subtle.

1. Assume That Your System Can Be "Smart"

Powerful data processing and logical microcircuitry are available at costs which are low in terms of the cost of any significant-sized system. Currently, their use may well be limited by the relatively small number of people who are "at home" with these devices, and the "cultural" notion that cars, houses, machines, etc., are relatively passive and not very intelligent. (No arguments about my use of the word intelligent, please.)

Although I won't go into detail on intelligent systems, I offer one piece of advice: when designing a system, start out by asking yourself what are all of the possibly advantageous measurements, calculations, decisions, controls, checks, signals, etc., that the system might make on itself and its behavior. Then eliminate only those which are, in comparison to their value, impractical on the basis of cost or probable need for maintenance.

2. Don't Build in Unnecessary Precision

Regarding this point, I am reminded of x-ray diffractometers, a type of research instrument which I have used (and designed) myself. With an x-ray diffractometer one generally rotates a sample and a detector, independently, in one or more dimensions, to measure the intensity of an x-ray beam incident on and scattered by the sample as a function of the angles of incidence and scattering. The rotations are accomplished by hand-operated knobs, or by motors, through highly precise gear trains. The gears "must be" precise so that one can set the relevant angles exactly by carefully controlling the motors. Most people, therefore, naturally expect that the largest part of the cost of such a diffractometer is in the precision of the gears. Of course, even without computer control of the unit itself, x-ray data is usually computer-analyzed. Therefore, whether the angle scale is precisely linear is actually irrelevant, since conversions can be made; in fact, a conversion from the nominal independent variable, Θ, to sin Θ is often part of the analysis anyway. Thus, what *is* required in this instance is not precision but *reproducibility* — and a calibration. Usually, of course, the latter is much easier, and less costly, to achieve.

3. Control the Output, Not the Input

I'll use the x-ray diffractometer to illustrate this point, too. Suppose we take the further step of controlling the diffractometer — or any spectrometer — by computer. One method would be to have the computer turn the motors on and off as required by the intended motions, the gear ratios, and the motor speeds; we would depend, then, on the gear and motor precisions or the calibration curves previously referred to. A more effective arrangement would be — if possible — to put some instruments on the relevant sample and detector shafts which generate an output that directly measures their orientation. These instruments are then used to control the diffractometer, and the system becomes independent of inaccuracies due to the motors, the gears, the bearings, etc.

4. Find Out What the Problem Really Is

Too often, engineers — particularly specialists — spend all their time solving solutions. That sounds strange, I'm sure, but it is what happens. A manager may ask you for a metal which will operate for ten years at 1000° C. in an oxidizing atmosphere." If you think of yourself as a materials engineer, that will sound like a problem; it will be phrased just right for the framework in which you've been trained to think.

However, the actual problem may be lost somewhere in the history of the technology for which that metal is now wanted. The metal may be needed, for example, for the blades of high-temperature, electricity-generating gas turbines to be driven by the gaseous products of a particular fuel combustion cycle. The problem, as posed, may really be somebody else's notion of a good solution. To figure out the extent to which this is the case you might ask: "What is the metal for? Can the blades be water-cooled? Can the chemistry be changed to make the atmosphere reducing? Do the blades have to be metal? Is a turbine the best way to get electricity in this case? Why is

Engineering systems should draw on large servings of common sense. Here are some of the simple ideas that are not so simple to keep track of

the electricity needed?" And so on. When you begin to ask such questions seriously, you're beginning to think like an engineering systems person.

Of course, the critical thing is to know what questions to ask and when to stop asking. Master that well and you'll be thought of as an incisive thinker, an engineer who really gets to the heart of the matter. Do it poorly and you'll be known as the kid who keeps asking. . . . Remember also, that it isn't very useful for all such sessions to end up with a demonstration of the impenetrable depths of your profundity; such basic and fascinating questions as, "Why *did* our ancestors come down from the trees?" should be used with a measure of restraint.

5. Be Sure the Basic Economics Are Sound

From this subtitle, you may expect a discussion of things like capital, interest rates, wages, and so on. An engineer *does* have to worry about those things, because he operates in a context in which they play an important role. But they don't really constitute the basics. We should remember that "financial" mechanisms and procedures were set up to *facilitate* the doing of business, the development of industry, and the distribution of goods and services. So we should be curious and even aggressive if the purely monetary aspects of a situation seem to be holding back, rather than facilitating, a development that otherwise appears to be highly desirable. Did the South Pacific natives allow themselves to starve to death when the sea shells (or whatever they used for money) were in short supply?

There are, in fact, three really basic things that determine whether or not we can do something:

— Do we have access to and can we use up the raw materials required — including fuels, of course? (Recycling possibilities only change the details of this point.)

— Do we know how to do it?

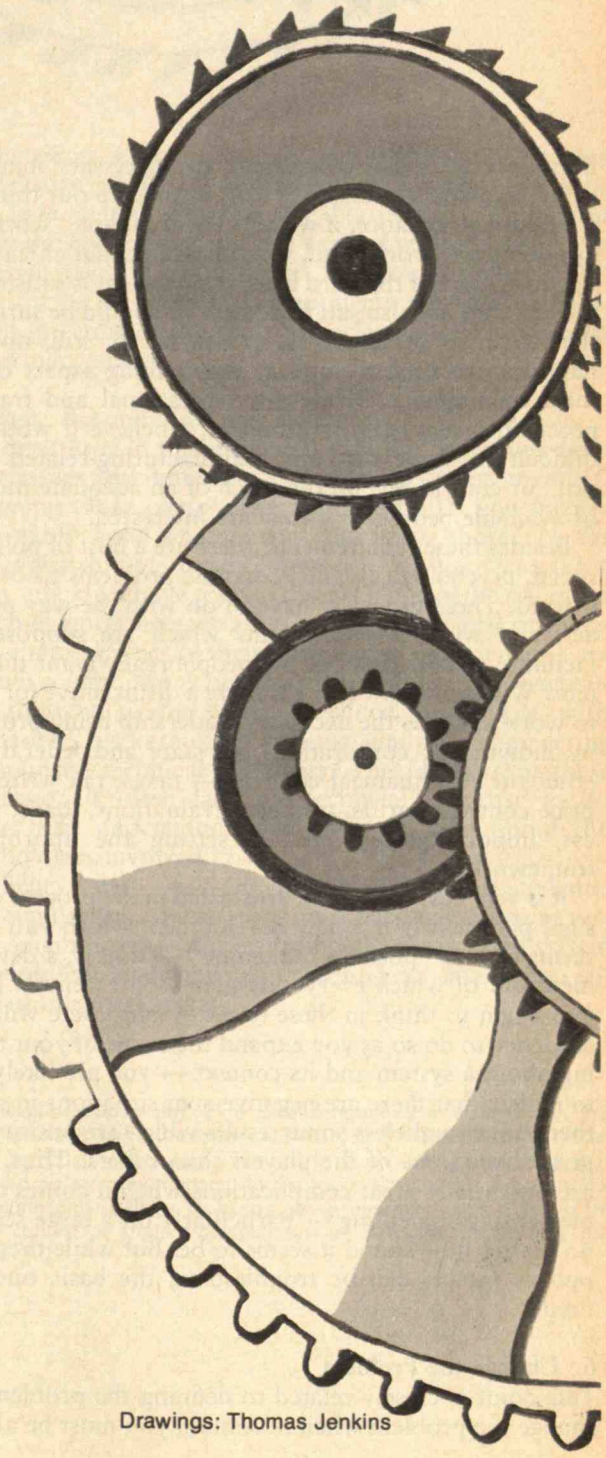
— Do we have the people to do it? (If the bodies are available but not the skills, do we have the people — or other means — to provide the training?)

When the development is itself intended to augment one of the other basics (e.g., fuel, people, a material), there is a fourth:

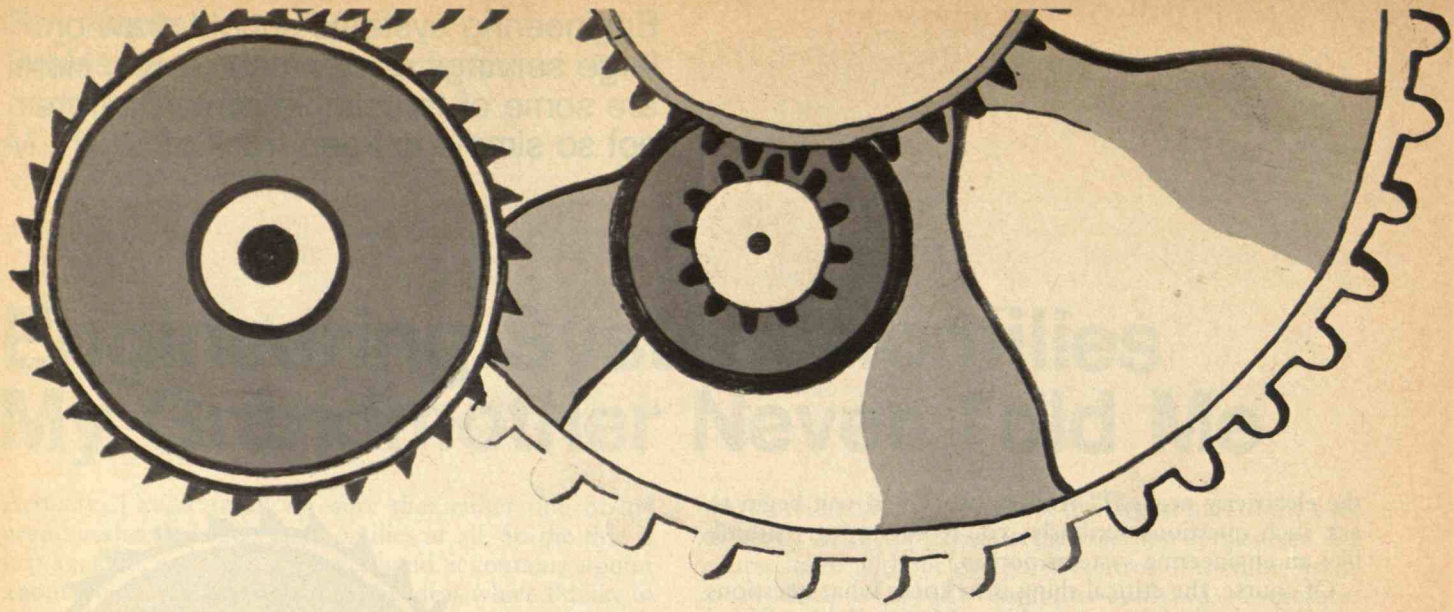
— Will it replace more than it consumes?

From the viewpoint of system design, these requirements are critical. We really shouldn't proceed without being sure that they are met. Negative answers should give us clues as to where basic research — in science, engineering, and education — could have a useful impact.

We need to remember, of course, that in our opera-



Drawings: Thomas Jenkins



tional world these conditions are necessary but not sufficient. Nonetheless, they help us to keep our thinking straight. For instance, if we have eight million "workers" not doing any work at all, we can assume that at least the "people" part of the third basic requirement is satisfied. If the first two are also satisfied, then we should be sure that the fourth (if pertinent) is, or can be. If, still, nothing happens, we need to look at the training aspect of the third requirement. While our educational and training procedures may still be primitive, I believe it would be difficult to argue that any manufacturing-related task, skill, or craft is beyond the reach of an adequate number of available people — if they are interested.

Besides these requirements, there are a host of political, social, psychological, and economic problems to be considered. These generally have to do with the way people act, and whether mechanisms which are supposed to facilitate actually inhibit. Do people really want the system? Will they work on it? Is there a disincentive for them to work at all? Is the necessary leadership being provided by individuals, corporations, or state and federal government? Are financial controls — taxes, tax write-offs, price controls, tariffs, property evaluations, loans, interest, import quotas, etc. — setting the appropriate framework?

It is very easy to become frustrated in the process of design, particularly if a new development which you favor seems to be a "positive-sum-game" — that is, a development out of which everybody gains some benefit. But if you begin to think in these terms — and there will be a tendency to do so as you expand the scope of your thinking about a system and its context — you are likely also to realize that there are negative-sum situations in which there are nonetheless some results which are positive and greater for some of the players than others. Thus, there are potentially great complications when it comes to implementing something — particularly on a large scale — no matter how sound it seems to be. But while these secondary factors can be troublesome, the basic ones are fatal.

6. Change the Problem

This point is closely related to defining the problem. To change the problem when necessary, you must be able to remember the purpose that you're trying to satisfy while you're working on a solution. If the approach you've chosen begins to seem impractical, be ready to discard it in favor of another one.

Usually, of course, the new approach will have its own set of not-yet-solved problems. Only rarely, if ever, will your new solution fall into place *en masse* . . . "there it is, in all its glory and detail." More often you will exchange one set of problems for another on the basis that you're more likely to be able to handle the new ones than the old.

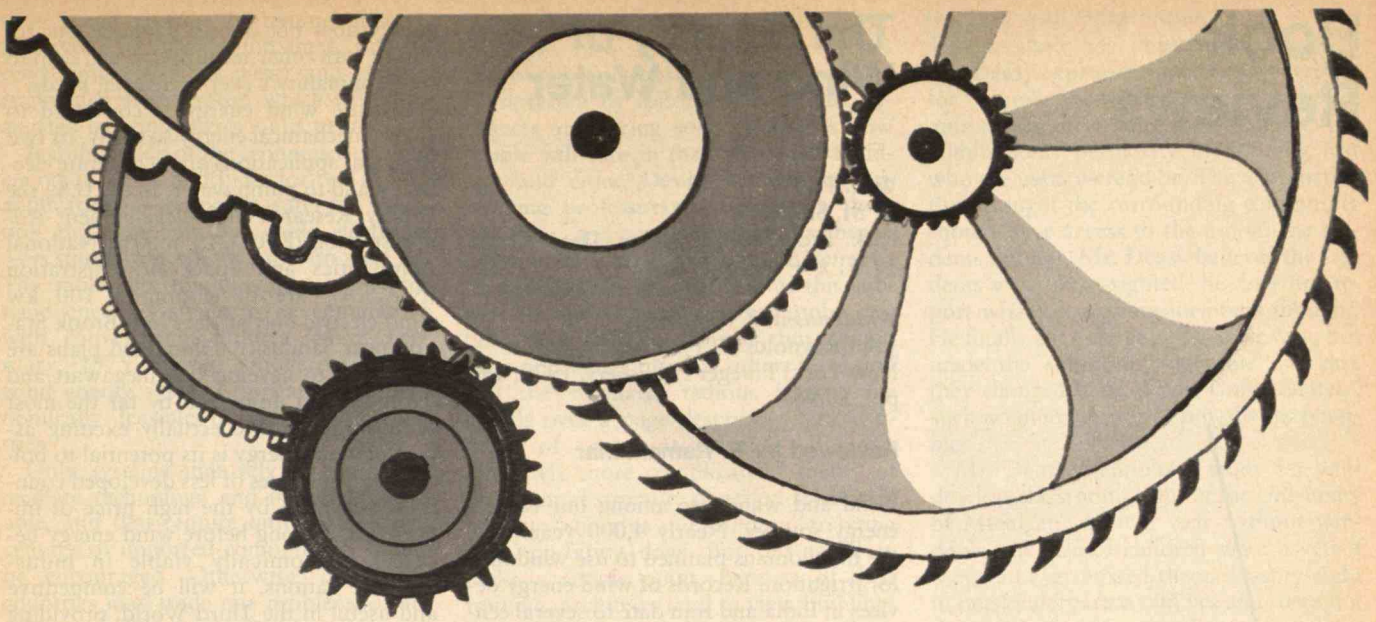
Without knowing the actual history, I can imagine that the development of a material to allow re-entry of a nose-cone into the earth's atmosphere may have followed such a route. The entry of the nose-cone at high velocity generates a lot of heat. A reasonable approach would be to develop a material capable of maintaining its full structural integrity at the temperatures generated. We might call this the "brave-it-out" approach. However, as most of you know, another solution exists based on an entirely different philosophy. A coating material can be used to absorb the heat of re-entry at fairly high temperatures and totally *disintegrate* (ablate) in doing so, carrying with it into space the thermal energy that would otherwise have destroyed the nose cone.

It is sometimes difficult to change problems in midthink. Alternative approaches do not pop out of a random-number generator, nor are they necessarily associated with an easier-to-solve set of problems. Try to be receptive to new approaches when they do come. Too often we have an emotional involvement with an earlier approach, and our "investment" in it makes us too reluctant to change. The aversion to failure is so ingrained and somehow so easily attached to a particular attempt that our desire to make it work at any cost clouds our receptivity to alternatives.

7. Change the Application

Here is another rule whose use depends on maintaining mental flexibility. Now, however, you must keep in mind not only the purpose that you are trying to satisfy at the given time, but a much more general set of things that are worth doing.

The point is that while you're trying to accomplish one



thing you may do another. This is not likely to occur for a whole system, of course, especially if you've designed your engineering efforts with a knowledge of and a sensitivity to the specifics of the original purpose. It can happen with specific pieces or concepts, however, and so you need to be sensitive to how such pieces can function alone, or as parts of other systems. After you've identified such alternatives, you will have to be prepared to do a "selling job" on others who have not yet understood this rule, so you may often start with someone who is not interested in anything except the original application.

8. Modify the Application

For this, one needs to maintain a flexibility of goals. Suppose, for example, that you aim to develop an electric car, capable of traveling 55 m.p.h. for 400 miles on a single charge. Suppose your efforts yield "only" 40 m.p.h. maximum speed for 150 miles. Might such a vehicle serve adequately for an in-town taxi fleet?

Consider another area, solar energy. We have become accustomed, over the years, to steady energy availability through electric cables, gas pipes, and propane, gasoline, and oil tanks. Therefore, we consider that solar energy is extremely inconvenient, going on and off as it does at least once a day (on earth). Engineers are working, of course, to make solar energy seem to be as steady as the other sources we have grown accustomed to. On the other hand, here's a little exercise for you: make a list of all the things which can be done with solar energy in which it will be perfectly all right if the action simply starts and stops with the rising and setting of the sun.

9. Analyze the System as a Throughput Device

Some parts of any complicated system will limit its ultimate performance while others will be underutilized. For instance, a small time-shared computer, with a memory of magnetic disks, is very likely to be limited by the rate at which transfers can be made to and from the disk secondary memory unit, *no matter how else you improve it.* In such a situation, *that* fact should determine many of the other system parameters, such as: the processing speeds needed, the amount of fast memory, the design of the software user-switching algorithms, the number of terminals that should be connected simultaneously, and so on.

The point is this: accurate system simulation studies are feasible when you understand the system, and these will help you to pinpoint the bottlenecks. When you know the bottlenecks you can expend your efforts where they will have the greatest effect, and you can avoid building systems in which the components are highly unbalanced in terms of the ratio of performance available to performance used.

Systems: Beyond Nuts and Bolts

I've dealt little in this discourse with the direct nuts-and-bolts issues of connecting system components together, designing those components, and so on. If you have a reasonably good engineering education, those are the things which you already know how to do or can learn fairly quickly. I have tried to discuss some of the issues for which engineering specialists — because of real or imagined characteristics of their training and experience — are seldom sought. Many of these more "global" perspectives are thought to be better provided by people with "broader" backgrounds: systems analysts, engineering economists, technical managers. The fact is that these professionals often lack the technical expertise to do more than understand what they are told about the technologies involved.

I believe that *we* — engineers, engineering students, and engineering educators — must become experts at systems engineering — not regarding just the isolated system in a void but analyzing and designing systems in the context of our total society.

Roy Kaplow studied physics as an undergraduate at M.I.T. (S.B., '54) and continued for his doctorate (Sc.D. '58) in the Department of Metallurgy and Materials Science. This article of advice to systems engineers is based on remarks prepared by Professor Kaplow for a symposium of engineering students designing energy resource alternatives in the 1976 contest of Student competitions on Relevant Engineering, Inc. (S.C.O.R.E.).

Book Reviews

The Energy of Wind and Water

Wind Power
D. M. Simmons
Park Ridge, N.J.: Noyes Data Corp., 1975; x + 300 pp., $24

Windmills and Watermills
John Reynolds
New York: Praeger Publishers, 1970; 196 pp., $8.95

Reviewed by R. Ramakumar

The energy in the wind may seem a tiny morsel against America's tremendous appetite for power. But consider it in the very different context of the one billion people in the Third World for whom one kilowatt per person per day would represent a dramatic transformation in life itself. (Photo: Bohdan Hrynewych from Boston Wind)

Wind and water are among our earliest energy sources. Nearly 4,000 years ago, the Babylonians planned to use windmills for irrigation. Records of wind energy devices in India and Iran date to several centuries before Christ. The use of fossil fuels is comparatively recent in history and has had disastrous effects on society and the environment. It created oases of developed nations and reduced masses of people in isolated, rural areas to perpetual penury.

Now, as our fossil resources are depleted, people are reflecting on the simpler ways of the past, and looking to windmills and watermills once again to find solutions for the present.

The federal wind energy program has grown from a very modest $200,000 funding in 1973 to $12 million this year. This phenomenal growth in government outlay has focused attention on wind power and spawned numerous publications, research projects, and claims. Mr. Simmons' and Mr. Reynolds' books are among them.

Mr. Simmons summarizes his findings on wind power, collected from various books, conferences, and workshop proceedings. Yet the knowledgeable reader will be uncomfortable with his book on two counts: errors and omissions are difficult to avoid, and the technology of wind power continues to develop, making it difficult to keep up to date. Nonetheless, few books present as much information on wind power as this one.

Mr. Reynolds' painstaking study of windmills and watermills is coupled with an excellent collection of photographs. His book is a valuable reference, and the mechanical genius evidenced in the early designs it presents should be an inspiration.

Wind is air in motion, created and continually regenerated by a small fraction of the insolation reaching the outer atmosphere. It is estimated that nature generates wind energy over the earth's land area at a rate of 1.67 (10^{15}) kilowatt hours (kwh) annually. Energy available in winds over the globe is at least ten times that figure. Obviously, only a small fraction of the total can be harnessed for use. So wind energy does not offer a panacea, but together with other resources, it can help to fulfill humanity's ever-increasing needs.

Because wind energy is converted to rotary mechanical energy so easily, its two principal applications are to generate electricity and to pump water. In the U.S., the Energy Research and Development Administration (E.R.D.A.) and the National Aeronautics and Space Administration (N.A.S.A.) are developing a 100 kw wind-electric unit at the Plum Brook Station near Sandusky, Ohio. And plans are underway to develop one megawatt and ten megawatt units. But by far the most promising and intellectually exciting aspect of wind energy is its potential to bolster the economies of less developed countries weakened by the high price of imported fuel. Long before wind energy becomes economically viable in industrialized nations, it will be competitive and useful in the Third World, providing badly-needed energy for food production and other basic services.

The cumulative impact of even small amounts of intermittently available energy in less developed countries can be considerable. Nearly 1 billion people live in isolated communities of 50 to 100 families. And an estimated 1 kwh per person per day would improve their living conditions dramatically.

Several possibilities exist for harnessing wind power in developing countries. One or more small wind energy units (less than 50 kw) can be used by groups of customers to supplement the electricity supplied by rural lines. Banks of wind energy systems located in windmill "farms" can be employed to pump electricity into a power grid whenever wind velocity is sufficient to permit this fuel-saver mode of opera-

Application	Cost ($/kw) Egypt	India
Irrigation using centrifugal pump powered by 5 horsepower diesel engine	317.42	360.43
Irrigation using centrifugal pump powered by 5 horsepower induction motor, fueled by utility main	443.61	192.23
Household electric supply from utility main	473.37	473.37

For wind energy systems to be competitive in Egypt and India, they must better the costs of conventional power generation, shown in the figure above. (Table: R. Ramakumar, "Harnessing Wind Power in Developing Countries," I.E.E.E. Catalog, 75, August, 1975.)

tion. Small clusters of remote villages, connected by distribution lines, can receive power from a diesel and bio-gas engine-driven generator, which would be assisted by wind energy units nearby.

A comparison of the economics of wind energy in Egypt and India for two typical applications — pumping water for irrigation and supplying household electricity — is summarized in the table on page 62. The table sets the maximum costs for wind energy systems to be competitive with conventional utilities (as of February, 1975). Given innovative design, wind energy systems appear to be economically feasible in developing countries.

Only systems that rely on the intermediate technology and materials available, and that require only a small percentage of imported components, should be encouraged. Otherwise, developing countries may trade one problem for another, equally critical. But handled with sense and sensitivity, the development and exportation of wind and water energy technology may be one of the best forms of foreign aid we can provide.

R. Ramakumar is Professor of Electrical Engineering at Oklahoma State University, following a ten-year tenure on the faculty of Coimbatoire Institute of Technology in India.

The Limits of Architectural Diplomacy

Design for Human Affairs
C. M. Deasy
New York: John Wiley & Sons, 1974; 183 pp., $15

Reviewed by Jonathan Schlefer

Fifteen years ago, Jane Jacobs proclaimed in *The Death and Life of Great American Cities* that planners' and architects' approach to cities was as up-to-date as blood-letting in medicine. She may have been polemic, but she was largely right. Le Corbusier was far off the mark when he imagined that the way to cure urban ills was to clear decayed areas and erect high-rises in a park. Perhaps the point has been belabored too long now, but the stark facts still speak with force. In *Defensible Space* (1972), Oscar Newman compares low walk-up housing projects, where each area, inside and out, clearly belongs to some group of families, with high-rises whose corridors, elevators, roofs, and entrances are used by so many that they become, in effect, no-man's-lands. In some adjacent projects, the high-rises have crime rates three times that of the walk-ups.

Impressed by lessons such as this, architects are asking social scientists how people will fare in their proposed buildings and cities. Design schools are appointing professors to investigate these questions, and a new literature has begun to grow. In *Design for Human Affairs,* C. M. Deasy gives an overview of this subject. He makes some interesting observations, but they are spread thin among lame rehashings of what others have said and the standard, tedious jargon. He spends over a page describing "the concept of associationism," Piaget's "infinitely more complicated" theory of the "mental structure of action-schemes," and our "stimulus and response" to biting and non-biting dogs. But this is all to make a simple point. Because of their training, architects tend to view buildings through fixed convictions; these may have little to do with the way clients see buildings or the way people behave in them.

Learning the Constituency

The most interesting story Mr. Deasy tells is of the collaboration between his own architectural firm and Thomas Lasswell, a professor of sociology at the University of Southern California. He describes in some detail their work on the student union for California State University at Los Angeles. With helpers, Mr. Deasy and Dr. Lasswell made systematic observations of all non-academic areas of the campus and interviewed selected samples of students, college employees, and community leaders.

One surprising point the interviews turned up was (as Mr. Deasy reported in an article for *Psychology Today*) that "the students weren't really interested in a student union": a startling, important result, and one most architects would never have stumbled across. They found the students nonetheless had certain needs and wishes, and were able to design for them. The building was to contain essential services such as a book store and career information, interspersed with free activities suited to the students' pocketbooks and their few moments of spare time. Both faculty and students had said they wanted opportunities to meet outside class, and the architects deliberately tried to lure faculty into the union. They recommended, among other attractions, concessions serving quality food, beer, and wine. Their observations suggested that the building would be used only if it were beside the main campus throughfare, so Mr. Deasy's firm put it there, even though the site presented difficulties. Since students often studied by entrances, they designed comfortable study places in the plaza in front of the building. The final result is surely better than the usual product, created by some alchemy of administrators' preconceptions, architectural images, and thin air.

Dealing with Differences

This method has limitations, however. Mr. Deasy expresses a hallowed reverence for "users"; but what do you do if the requirements of various users conflict? He admits some perplexity in deciding just who the users were to be. The administration thought the surrounding community should have access to the union; the students did not. Mr. Deasy believes the students were short-sighted; he does not report what community members thought. He finally gave the students their way, but made the solution "adaptable" in case they changed their minds. Unfortunately, such accommodation is not always possible.

Mr. Deasy mentions a study on windowless classrooms done at the University of Michigan. After a year without windows, the school children were asked if they had ever missed them. Twenty-eight in one kindergarten said yes and three no; the third graders missed windows least (13 yes's and 13 no's). However, all but one teacher preferred windowless rooms: when there are windows, "the children can see the nice weather and it is harder to keep their attention." If you cannot please everybody, whom do you accomodate?

These researchers solve the dilemma by simply ignoring the students' responses. They allege the children showed "very little personal interest in whether their classrooms had windows or not," and reason shabbily that it is probably all right to do away with school fenestration. Dr. Lasswell has an equally deadly way to take care of differences: "The object is not so much to design this building so that everyone in it will be happy as it is to design it in such a way that it is *possible* for anyone in it to compromise his individual goals in favor of the total organization."

It is odd that Dr. Lasswell and the University of Michigan researchers lost track of the wants of building users — the very thing they were presumably looking for in the first place. This can happen if "behavioral science" is used as a neutral cover for conflicts. Even when you cater conscientiously to majority interests (the Michigan researchers apparently did not), is it right to disregard the exceptions? Mr. Deasy glosses over this question. Jane Jacobs did not; in 1961 she warned against planners who "regard 'unaverage' quantities as relatively inconsequential, because these are *statistically* inconsequential. They have been trained to discount what is most vital."

Often there is no perfect solution: behavioral science can be invaluable in raising questions, but people must decide them.

Jonathan Schlefer is finishing his master's degree in architecture at the University of California at Berkeley. He has experience in interior design and model building, and has taught at the New Thing Art and Architecture Center in Washington, D.C.

Reminiscence and Prediction

In at the Beginnings:
A Physicist's Life
by Philip M. Morse

Philip Morse has surely been one of the most versatile of American scientists of this generation, the first to be trained largely in its own country. A scientific generalist, he made significant contributions during his years at MIT to atomic physics, quantum mechanics, plasma physics, astrophysics, acoustics, machine computation, and operations research. Moreover, as this autobiography relates at a fast-moving pace, Morse has also been intimately involved in the high-pressure concerns of war research, scientific administration and consultation, policy formation, the education of key groups and wider publics beyond the classroom, and the real-world utilization of scientific techniques and discoveries.

Morse's style is straightforward and nontechnical, direct and personal. Some of the lighter moments and revealingly human incidents of his experiences are recorded along with the problems and breakthroughs in the near-private world of pure science and the public worlds of policy, high-level consultation, and practical applications.

$14.95

On Systems Analysis:
An Essay Concerning the Limitations of Some Mathematical Methods in the Social, Political, and Biological Sciences
by David Berlinski

Here is a book of unrelenting negativism that takes on the modish motley of disciplines known as Systems Analysis, and exposes it as a largely empty sham—such content as it has turns out to involve artificial mechanisms that have no vitalizing core of meaning. Berlinski shows that where systems theory becomes specific it is not more than a collection of techniques of restricted applicability, and when it is most fully generalized it simply reduces to the class of content-free logical truths. Systems in general, he writes, have only their systemhood in common.

$15.00

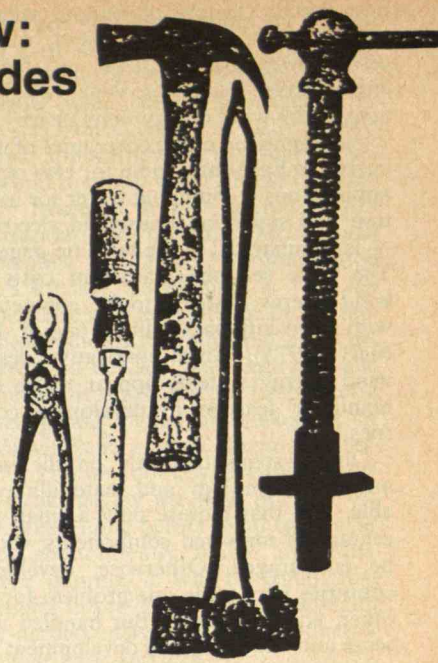
Energy Demand Studies: Major Consuming Countries
Analysis of 1972 Demand and Projection of 1985 Demand
The First Technical Report of the Workshop on Alternative Energy Strategies, Carroll Wilson, Project Director
$20.00

Now in paperback!

Bicycling Science:
Ergonomics and Mechanics
by Frank Rowland Whitt and David Gordon Wilson
$4.95 (hardcover edition, $12.95)

The MIT Press
Massachusetts Institute of Technology
Cambridge, Massachusetts 02142

The Turn of the Screw: Early American Attitudes Toward Technology



Civilizing the Machine: Technology and Republican Values in America, 1776-1900
John F. Kasson
New York: Grossman/Viking, 1976; xiv +274 pp., $15

Reviewed by Jeffrey L. Lant

One of the most revolutionary aspects of the American revolutionary era was the introduction and development of an ever more powerful technological capacity. Its importance can scarcely be exaggerated. For technology, and the changing social patterns it both reflected and fostered, challenged the prevailing vision of most of the Founding Fathers as they labored to bring about not merely a new political community, but the "new secular order" proclaimed by the Great Seal.

As the Fathers generally believed, this new order was to be agricultural, based on the independent ownership of land by farmers who would realize power, liberty, and virtue by practicing industry, frugality, restraint, and social service.

What might be called the mode of the yeoman farmer was not, however, invented by the Fathers, but rather accurately reflected the realities and hopes of the people at large. Any threat to the right to own property — no matter how vague — was sufficient to arouse much of the white male population to active and intense rebellion. Their ire was directed not only against the Crown and its designates, but also against the Fathers themselves (witness Shay's Rebellion under the Articles of Confederation).

It was for these independent farmers that the revolution was fought and to their interests that Thomas Jefferson, himself a farmer, spoke in his pamphlet, *Notes on the State of Virginia* (1785). There he wrote, "Those who labor in the earth are the chosen people of God, if ever he had a chosen people, whose breasts he has made his peculiar deposit for substantial and genuine virtue. . . . Corruption of morals in the mass of cultivators is a phenomenon of which no age nor nation has furnished an example."

Having cited such evidence as this, John Kasson concludes, "A republican society was a society of freeholders, and praise of husbandry amounted to a national faith."

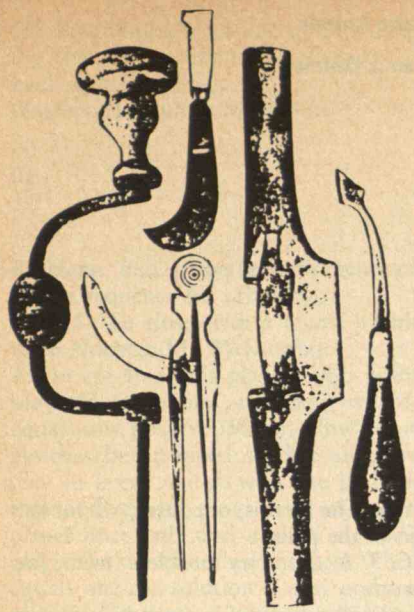
Instrument of Republican Virtue

But the success of the revolution depended in part on the timely development of domestic manufactures, through which "technology emerged as not merely the agent of material progress and prosperity but the defender of liberty and instrument of republican virtue." A dynamic tension developed between such transitional advocates of agriculture as Jefferson, and those advocates of a greater technology such as Tench Coxe, a Philadelphia merchant and contemporary of Jefferson.

Coxe, describing how the machine might be used to promote republican civilization, demonstrated how the development of industry might insure the nation's economic independence, and how machines might suppress dissipation and corruption in society by promoting "regularity, uniformity, subordination, harmony, efficiency," and similar virtues. He said, "A man oppressed by extreme want is prepared for all evil: and the idler is ever prone to wickedness: while the habits of industry, filling the mind with honest thoughts, and requiring the time for better purposes, do not leave leisure for meditating or executing mischief."

In an age of rapid change and profound consciousness of the possibilities for anarchy, this efficient ordering of society was attractive. Many thinkers and practical men were inclined to see in manufacturing an opportunity to restrain those people who were not tied to the land.

They also looked for other ways to preserve order. Benjamin Rush, for example, advocated the establishment of schools that would produce obedient "republican machines." In fact, from the earliest days of the republic, the educational system was encouraged to train passive and malleable citizens for the industries that needed them. (A number of school historians have noted this important linkage; most recently economic scholars Herbert Gintis and Samuel Bowles of the University of Massachusetts at Amherst have done so in *Schooling in Capitalist America.*)



So despite the country's agricultural allegiance, the promotion of technology to preserve and foster the social order quickly became an article of faith in the republican ideology.

One of the crucial testing places of this belief was the manufacturing town of Lowell, Mass., which Mr. Kasson identifies as an important social experiment. If American factories could do no more than produce the stunted lives and blighted environments endemic in English manufacturing towns, then perhaps the people's faith in technology was misplaced and ought to be abandoned.

The Bostonian entrepreneurs who developed Lowell, however, took pains to insure that no such result would take place. "Lowell promised to resolve the social conflict between the desire for industrial progress and the fear of a debased and disorderly proletariat."

And so it proved (for a time), for in Lowell a manufacturing system was fashioned "that concerned itself as much with the health, character, and well-being of its operatives as it did with profits." The consequence was that Lowell became another wonder in an age of wonders, about which the very critical Henry Colman could write, in 1836, "The moral spectacle here presented is in itself beautiful and sublime."

Agent of Social Dissolution

Unfortunately, the heady and largely uncritical belief in progress and in technology as the ally of republican values was not longstanding. While belief lasted, this technology became an important influence not merely in the manufacturing sphere but in the arts and letters, as well.

By focusing on the representative figure of Ralph Waldo Emerson, Mr. Kasson describes the transformation in attitude among 19th-century intellectuals from optimistic acceptance of technology to severe doubt about its usefulness and desirability. Emerson had first "celebrated technology as a stimulus to creative vision, [but] in his later career . . . emphasized more its tendency to debase the imagination."

It was a debasement that the vast majority of Americans gladly accepted, transported by prosperity into an indulgence in the materialism and sensuality which Emerson had warned against. Thus they failed to heed Emerson's jeremiad, delivered at Concord in 1851, that "Things are in the saddle/And ride mankind."

A more widespread intellectual realization of what Emerson had early recognized came at century's end, when a thinker such as Henry George could write, "The promised land flies before us like a mirage." Pointing to Edward Bellamy's *Looking Backward* (1888), William Dean Howell's *A Traveler from Altruria* (1894), and other utopian and dystopian novels, Mr. Kasson measures the failure of the republican dream, and discovers how many believed with Harvard professor Charles Eliot Norton that the fin de siècle was "a degenerate and unlovely age" of frustration, dissilution, and barbarism.

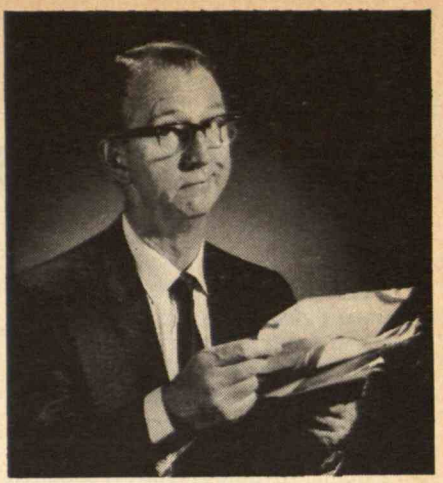
What happened during the mid-Victorian years in America, as in England, was that technological civilization signally failed its promise to direct the people towards that sturdy, independent society envisioned by the revolutionary leaders. Instead, it reduced the vast majority to mere subsistence, and elevated a tiny fraction to dazzling and conspicuous wealth.

Though the dream of a humane technological order persisted, the reality was stark and unrelenting. As the century ended, the abyss between the republic envisioned by the Founding Fathers and the rapacious — and regnant — industrial and technological order seemed wider than ever. The likelihood of ever reconciling them appeared most improbable.

The result? "Never again," writes Mr. Kasson, "would the concept of republicanism possess the centrality and coherence that made it, from the revolution through the nineteenth century, such an important shaping ideology in Americans' response to technology."

Unfortunately, we have only Mr. Kasson's word that this is the case. Perhaps he's right, but the author should have given us some evidence, and a more detailed look at what followed. It is not enough to say that "new political strategies and categories of value would have to be formulated to address the enduring and elusive problem of civilizing the machine."

Jeffrey L. Lant, who holds the Ph.D. in History from Harvard University, is Coordinator of Student Services for the Boston College Evening College.



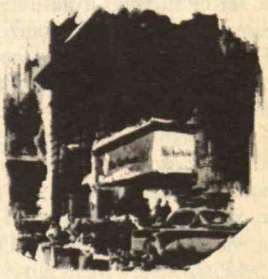
My job is to cut travel expenses.

. . . I did!

25% OFF REGULAR ROOM RATE

FOR FACULTY & STAFF

No complaints, either. They liked the comfortable accommodations, with modern amenities, fine dining and intimate bar (just right for entertaining or contract closing) and the location is unbeatable, near everything that matters.



The Gotham

Fifth Avenue at 55th Street
New York, New York 10019

Yes, we want the 25% DISCOUNT Rate

Name _____

_____

Address _____

City/State/Zip _____

(Please print. List additional names on separate sheet)

See your Travel Agent, or call:

New York	212-247-2200
Chicago	312-664-9335
Washington, D.C.	202-737-1002
Boston	800-225-1739
Philadelphia	215-665-8520
Toronto	416-962-5711

Horopters and the Price of Cheese

Puzzle Corner
by
Allan J. Gottlieb

Hello again. Autumn has just begun and the leaves are starting to turn. This is my favorite season and also the time when I miss New England the most. As the long-time followers of this column know, I spent a year in Santa Cruz, California (on the coast between San Francisco and Big Sur). Although the year-long climate there is the best I have ever experienced, my autumn vote still goes to New England.

This is also the beginning of a new school year. I remain with the (smaller) City University of New York. Perhaps I erred last year in listing my address as Coordinator of Computing. While that is an accurate title, I am still a faculty member in the Mathematics Department and have not been "promoted out of teaching" as several readers have been led to believe.

Now let me congratulate two active contributors to Puzzle Corner. Professor John E. Prussing has been named to a half-time revolving assistant deanship in the College of Engineering of the University of Illinois at Urbana-Champaign. Harry Nelson is now the editor of the *Journal of Recreational Mathematics*. Anyone wishing details should write to him at 4259 Emory Way, Livermore, Calif., 94550.

Two comments on Speed Problems: first, I could use more; second, the proposer's solution (if any) is given in the same issue as the problem (at the end of the column). Other solutions received to speed problems are mentioned only in exceptional cases.

I feel that J/A 1 was well stated. Many readers, however, misunderstood the problem. Let me clarify the point of confusion. You may *not* assume logical play. So for the sub-problem A = 2, B = 3, for example, you must find a position satisfying: 1) If White moves first, *any* sequence of legal moves leads to a White victory (this is A = 2); and 2) If Black moves first, *any* sequence of legal moves leads to a black victory (this is B = 3). Similar remarks hold for the other eight cases. Solutions will be given in the March/April issue along with those to this month's regular problems.

NS 4 is obviously nontrivial, as all answers received so far are wrong. Everyone has "proved" that all three are homeomorphic; this is false.

I received a copy of the *Alphabetic Number Table* from one of its authors, DB. In case anyone is interested, of the numbers from 0 to 1000, three is the 788th in alphabetical order, whereas III is the 903rd in the list of alphabetical roman numbers from 1 to 1000.

Unsolved Problem

Our first problem is another from the past. This never-solved problem first appeared in March, 1969:

NS 5 If a pair of triangles is not co-polar, the joins of corresponding vertices form a triangle and so do the intersections of corresponding sides. The original pair of triangles has been transformed into a second pair which can be transformed into a third and so on. How does the sequence of pairs of triangles behave?

New Problems

DEC 1 Our first new problem is from Frank Rubin, who writes: "Here is a new chess problem, which boasts an incontrovertible solution (indeed, two such solutions) and thus may help you keep out of trouble";

How should eight queens be placed on the chess board so that the total number of moves is maximum?

Mr. Rubin writes that this problem "has an obvious solution, which is eight non-attacking queens, a very well-known position. Needless to say, since this is a Rubin problem, the obvious solution is obviously wrong."

DEC 2 We continue with an offering from Winslow H. Hartford: An interesting series is the "paired" series: (1,1), (2,3), (5,7), (12,17), (29,41), (70,99), . . .

a. What is the next pair?

b. What is the "rule" for constructing the series?

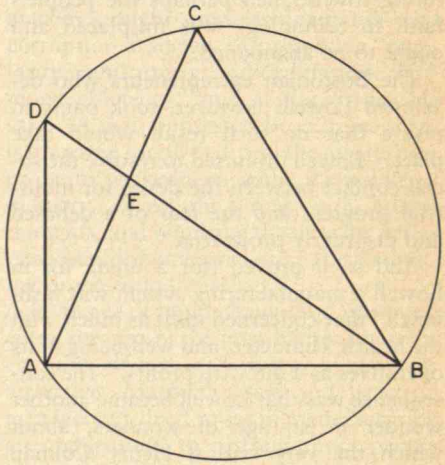
c. Show that the pairs give solutions to the equation:

$$2n_1^2 \pm 1 = n_2^2$$

and that the plus and minus signs alternate. The limit is, of course, $\sqrt{2}$ for the ratio of the pairs.

DEC 3 A geometry problem from Joe Horton:

Stated without proof in a psychology text was an interesting theorem about the horopter. The horopter is the set of points in space which, in traveling from one to another, subtend equal retinal angles. The horopter in a horizontal plane is a circle which passes through the centers of the lenses. In order to show this the necessary theorem was: Given a circle with a chord drawn, the vertical angle of any triangle constructed on that chord will be equal. Phrased that way, of course, it is not true — but if the constraint that the triangles be on the same side of the chord is invoked, then it is true. The problem: prove that given the circle shown, angle ADB = angle ACB.



DEC 4 Dave Kaufman poses an important problem in computer science (called the binary Gray Code):

For any positive integer n, there are 2^n distinct binary numbers of n binary digits (bits), leading zeros allowed. Here is the list for n = 2, arranged in counting order:

00
01
10
11

In decimal, they would read 0, 1, 2 and 3. In order to solve some problems in digital design, the list should be arranged so only

one bit changes from line to line, including the wrap-around case (bottom line back up to top line).
Here's one solution for n = 2:

00
01
11
10

Problem: find a method for generating such a sequence for arbitrary n.
DEC 5 We close with a tennis problem from Norman M. Wickstrand:
There are 4n tennis players who wish to play 4n-1 doubles matches, where n equals any positive integer. How can the matches be arranged so that all players play in every match with the limitation that each player plays with each other player once only and against each other player the same number of times? When n equals one the solution is easy and quite obvious. Is there a general solution or formula or system? Is it limited to perhaps n equals 5 or 6?

Speed Dept.
SD 1 Our first speed problem is from R. Robinson Rowe:
As an exercise preparing for adoption of the metric system, interpret the following nine quantities as units to become obsolete; their initials, in order, will spell a non-metric unit which will survive:

20.12 cm.
2.54 cm.
118.3 $cm.^3$
10.16 cm.
907180 g.
91.44 cm.
45.72 cm.
40468726 $cm.^2$
502.92 cm.

SD 2 We close with a quickie from Sam Gutmann: Joe Gourmet and Jane Gourmand made a bet (about a question of fact). The loser was to pay the winner one pound of Brie. Yet the stakes (not the odds) were two to one. Impossible?

Solutions
JUN 1 The dealer is North, and East-West are vulnerable:

North:
♠ 4 2
♥ K 10 8 7 6
♦ A J 5
♣ Q 4 2
South:
♠ A Q 10 3
♥ A Q J 9 5
♦ 4
♣ A 8 3

The bidding:

North:	South:
Pass	1 ♥
3 ♥	6 ♥ (!)
Pass	

The opening lead is ♦ 3; trumps are divided 2-1. Plan the play.

The answers I received look different and I'm far from an expert at bridge (as you doubtless know). Thus I am choosing Elmer Ingraham's primarily due to its clarity:

In a bridge game with this problem I would see that 12 tricks are sure if both black Kings are under their Queens, chancy if both are in the same unseen hand, impossible if both are over the Queens.

I would plan the play to discover if there is a sure way to go and to exploit whatever chances may develop along the way, much as detailed below:
1. I will play ♦A, 4, ♥6, 5, and ♥7, A to win the first three tricks, then lead ♣3 toward ♣Q.
2. If East can play ♣K to win the fourth, no return will hurt me if he has ♠K and ♠J in his hand or if West has no more than ♠J, x, x, for I will win all the rest in timely order with three high spades, one spade ruff, two diamond ruffs, the ♣A, and two more trumps for 12 tricks.
3. (a) If West has ♣K he may choose to hold off the fourth trick; ♣Q will win and I will lead ♠2 thru East at the fifth; if West can win with ♠K I can win any return and in timely order all the rest if ♠J will appear in three demands, for 12 tricks made.

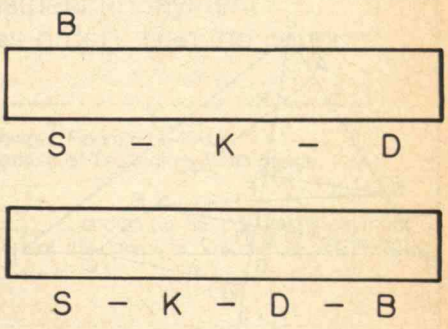
(b) If West has held off the fourth and cannot win the fifth I will cross to Dummy to lead ♠4 thru East at the seventh to win ♠A and ruff ♠3 at the eighth; if both ♠K and ♠J have then appeared I will win the rest in timely order for 13 tricks made, or if ♠10 cannot hold I win 12 tricks.
4. (a) If West plays ♣K to win the fourth trick he can return any spade I can claim, or win, all the rest in timely order with two high spades, two high clubs, two spade ruffs, two diamond ruffs and one more trump for 12 tricks made and the contract.

(b) If West has won the fourth and chooses to return any club or diamond, I can win all the rest in timely order if East has ♠K, for 12 tricks bid and made.
Responses were also received from R. Robinson Rowe, William J. Butler, Jr., Neil Cohen, and Richard I. Hess.
JUN 2 Four people — Kevin, Deb, Breck, and Sally — occupied a side table at a recent banquet. During the height of the festivities one of them slipped behind a nearby drapery and a few minutes later emerged to streak down the center aisle and across in front of the head table, out into the corridor, and back to the drapery — shortly to return and reocupy the vacated chair. When the excitement had died down somewhat the chairman of the banquet committee questioned the four to find out who had reoccupied the vacant chair.
Kevin answered:
1. I sat next to Deb. It wasn't her.
2. Breck or Deb sat to my right.
Deb said:
3. I sat next to Breck.
4. Kevin or Breck was on Sally's right.
Breck replied:
5. I sat across from Sal.
Sally said:
6. Only one of us is lying, and he or she is the guilty one.
Who was the varmint without a garment?

Michael Bissell had little trouble locating the streaker:

Assume Sally is lying. Sally's statement consists of two parts: A: "One of us is lying"; and B: "He or she is the guilty one." Sally would be lying if either part "A" or "B" of her statement is false or if both are false. A false part "A" implies that more than one is lying. A false "B" implies that he or she is innocent. The combinations of a false part "A" and a true or false part "B" can be eliminated since they result in a nonsensical statement. The remaining false statement which Sally could make would be "One of us is lying, and he or she is innocent." This combination requires that Breck, Kevin, and Deb are telling the truth, which is impossible since Breck's statement "I sat across from Sal," Deb's statement "Kevin or Breck was on Sally's right," and Kevin's statement "I sat next to Deb," can result in only the one seating arrangement shown below if all statements are true. However, this arrangement precludes Deb's statement "I sat next to Breck" from being true. Therefore, we can conclude that Sally is not lying.

Since Sally is not lying, there is only one liar and he or she is the guilty one. Assume Kevin is lying. However, since he made the statement "It wasn't her" in reference to Deb, it is implied that Deb is guilty, which contradicts Sally's statement. Therefore Kevin's is not lying. Assume Deb is lying. But this contradicts Kevin's statement that it wasn't Deb. Therefore, the only remaining alternative is that Breck is lying. The only non-contradictory seating arrangement assuming Breck is the liar is shown below. Sally's statement implies that Breck is the varmint without a garment.



Also solved by Mary Lindenberg, Harry Zaremba, Charles Rozier, Alan Baumgardner, Neil Cohen, Richard I. Hess, William J. Butler, Jr., Gregory James Ruffa, R. Robinson Rowe, R. Bart, and the proposer, James Cassidy.

JUN 3 Given a 4 x 4 array with markers in all but one of the squares (as shown); the object is to remove all markers but one by jumping horizontally or vertically (no diagonal jumps allowed), or else to prove that it cannot be done.

Perhaps this problem should have explicitly defined the word jump. However, I feel that the checkers (or Chinese checkers) terminology should apply. Thus you cannot "jump off the board." With this restriction the task is impossible, as Jeffrey Kenton cleverly shows:

Color the squares in the array as indicated:

1 Red	2 Blue	3 Green	4 Red
5 Green	6 Red	7 Blue	8 Green
9 Blue	10 Green	11 Red	12 Blue
13 Red	14 Blue	15 Green	16 Red

Notice that for any legal jump the starting square, middle square, and end square are all different colors. This coloring scheme is essentially unique. Let R, G, B represent the number of occupied red, green, and blue squares, respectively, in the initial position. Similarly, let R′, G′, B′ represent the final position. Let r, g, and b represent the number of moves (jumps) which *end* on red, green, or blue squares.

Then, $R' = R + r - g - b$

$G' = G + g - r - b$

$B' = B + b - r - g$

or, $\Delta R \equiv R - R' = g + b - r$

$\Delta G \equiv G - G = r + b - g$

$\Delta B \equiv B - b' = r + g - b$

which gives $2r = \Delta G + \Delta B$

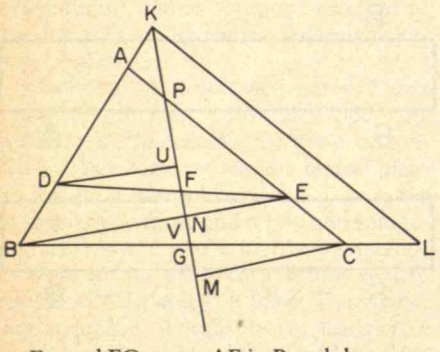
$2g = \Delta R + \Delta B$

$2b = \Delta R + \Delta G$

Responses were received from Harry Zaremba, Richard I. Hess, William J. Butler, Jr., and R. Bart.

JUN 4 Given any triangle ABC, choose points D and E such that BD = EC. Draw FG such that DF = FE and BG = GC. Then prove that FG is parallel to the bisector of angle BAC.

The following solution is from Leon Bankoff:



Extend FG to cut AE in P and the extension of BA in K. Draw KL parallel to AC, cutting BC produced in L. Since triangles ABC and KBL are similar and similarly placed, the proof is now reduced to showing that KG bisects angle BKL. Let α and β denote angles BKG and GKL (or GPE), respectively. Drop the perpendiculars CM, EN, BV, and DU upon KG. Then it is seen that CM = BV and EN = DU, which is equivalent to

$PC \sin \beta = BK \sin \alpha$ (*) and

$PE \sin \beta = DK \sin \alpha$. It follows that

$$\frac{PC}{BK} = \frac{PE}{DK} = \frac{PC - PE}{BK - DK} = \frac{EC}{BD} = 1, \text{ or}$$

PC = BK, which, substituted in (*), yields $\sin \beta = \sin \alpha$.

Hence KG bisects angle BKL, and FG is parallel to the bisector of angle BAC.

Also solved by R. Bart, Richard I. Hess, William J. Butler, Jr., Harry Zaremba, Ronald Goldman, John C. Gray, Burnham H. Dodge, R. Robinson Rowe, Neil Cohen, John Purbrick, and the proposer, J. Harvey Goldman.

JUN 5 Recall that this problem was modified in the October/November issue; the solution will therefore appear in the February issue.

Better Late Than Never

JAN 3 Emmet J. Duffy has responded.

JAN 4 Jeannette Roth has responded.

FEB 1 Eric Jamin has responded.

FEB 2 M. Fuerst claims that the hardest part is obtaining 129, 976, 320 as the number of complete closed routes over a heptagon with its diagonals. I agree.

FEB 3 Was proposed by Harry Nelson.

M/A 2 N. Peterson points out that the golden ratio is also the limit of

$$\sqrt{1 + \sqrt{1 + \sqrt{1 + \ldots}}}$$

Forrest Meiere points out a small error in the published solution. The statement, "Any sequence of numbers formed according to the rule $U_{N+2} = U_{N+1} + U_N$ will exhibit the property that the

$\lim_{N \to \infty} U_{N+1}/U_N = (1 + \sqrt{5})/2$."

has one exception.

Try $U_N = \alpha^N$ with $\alpha = (1 - \sqrt{5})/2$. The general U_N is $cF_N + d\alpha^N$ for suitable c and d with your statement true if $c \neq 0$.

M/A 3 P. Bonomo and Elliot Roberts noticed that the formula for T also occurs in formulas for pendulums.

M/A 4 Winslow H. Hartford has responded.

M/A 5 Gregory James Ruffa has responded.

M/A SD 2 Robert Pogoff was misquoted in July/August. He did not claim that the published solution was correct only for low altitudes but rather that a simplification is possible for low altitudes. Dick Boyd also noticed this approximation, namely: the "horizontal distance" in miles is nearly 1¼ times the altitude in feet.

MAY 1 J. A. Faucher has responded.

MAY 2 Eric Jamin has responded.

MAY 3 Eric Jamin and Gregory James Ruffa have responded.

MAY 4 Eric Jamin has responded.

MAY 5 Eric Jamin, Harry Zantopulos, Gregory James Ruffa, and J. H. Meier have responded.

NS 2 Eric Jamin has responded.

NS 3 M. Fuerst noticed the solution in an issue of *Operations Research* last year.

Proposer's Solutions to Speed Problems

SD 1

L INK
I NCH
G ILL
H AND
T ON
Y ON
E LL
A CRE
R OD

And, if you care, a LIGHTYEAR = 9.4608×10^{17} cm.

SD 2 Joe bet that a pound of Brie cost $4, and Jane bet it cost $2.

Allan J. Gottlieb is Coordinator of Computer Activities and Assistant Professor of Mathematics at York College of the City University of New York. Send problems, solutions, and comments to him at York College, 150-14 Jamaica Avenue, Jamaica, N.Y., 11451.

Letters

Continued from p. 4

Wiesner points out that efforts to protect society against the health and other *external* effects of new technologies inevitably slow the process of innovation. The rates of innovation to which we have become accustomed have been made possible, it seems, only by ignoring external costs. The more rapid the pace of innovation, the less likely we are to correctly assess the external costs: an obvious example is the 20-year lag in the development of cancer from human carcinogens. But even where such basic biological time clocks do not delay our realization of the full impact of change, learning takes time. By the time we notice the costs of change, the innovation is already embedded in the social structure (as with the automobile), or already being supplanted by the next innovation.

It is at least possible that slowing the pace of technological innovation will allow time for further external costs to emerge and join those already recognized. Note that the rejection on economic grounds of the first-generation supersonic transport provided time for scientists to discover still more undesirable side-effects.

It is not enough to say that various environmental and health problems are external costs imposed by specific, insufficiently analyzed technological changes; rather, they are costs of the pace of technological change itself. Since in the aggregate, society seems to have decided that these costs are excessive, efforts to restore the pace of innovation are mis-

directed. Dr. Wiesner's proposal that society should bear the costs of new drug development, when a drug's benefits are outweighed by the costs of testing them for safety, merely slows the shift in emphasis from innovations having high external costs to those with lower costs. Given limited resources for investment, the pace of innovation is thus slowed even further.

If Dr. Wiesner is right that constant technological innovation is necessary to maintain present conditions of life, then those conditions may indeed be seriously impaired.

Carl Pope
San Francisco, Calif.

Mr. Pope is Air Quality Consultant to the Sierra Club. — Ed.

Dr. Wiesner replies:

I agree with Carl Pope that in many situations, external costs are a function of the pace of technological change itself. In fact, I tried to make the same point in my essay. I expressed a belief that the large scale of existing technology is certain to slow down the pace of change, and that this deacceleration could have its own brand of troublesome side-effects. Unlike Mr. Pope, I don't view this eventuality as inevitable.

I also disagree with Mr. Pope's statement that society seems to have decided that the costs of innovation are excessive, and that efforts to restore the pace of innovation are misdirected. That may be true in some special cases, but I believe society is far from a final judgment, if for no other reason than that there has not been enough information available to make a judgment. Society is trying to understand the manifold dilemma that exists. The drug safety issue is a case in point. There are well-recognized trade-offs between the costs of testing and the hazards of less-well-tested drugs, but the human cost of delaying and perhaps blocking a new drug therapy is less obvious, and often ignored.

I believe strongly that a continually improving condition of life depends upon continuing technological innovation; I am also optimistic enough to believe that overall the quality of life will continue to improve. Furthermore, I am not egotistical enough to believe that our era represents the high point in man's humanistic and intellectual achievements. I do believe that the next quarter century will see a variety of extraordinary challenges — including the problems that Mr. Pope and I have so inadequately touched on. There could be some very hard bumps on the road to that better life, but they are not all inevitable. A worthy preoccupation for many of us are the efforts to avoid them.

Technology Marketing and Sales

We are a high technology company that conducts government and industry supported research in solid state, nuclear and plasma physics. This research has resulted in a number of commercial products such as solar cells, solid state detectors, nuclear instrumentation, pulsed power systems and radiation sources. So far, sales and marketing have been conducted primarily by our technical staff. We now need an individual with a strong technical background and a genuine desire to become involved in sales and marketing to take charge of this important company function. This individual need not have significant marketing/sales experience but must have a B.S. or M.S. degree in physics, the ability to communicate, the willingness to work hard, possess organizational skills, and have a strong desire to succeed.

In addition to immediate take-over of electronic and nuclear instrument sales, duties will involve coordination of R&D proposals and the development of a geographically broad marketing plan for solar photovoltaics. The salary range is $14-18k with unlimited advancement opportunity. If you think that this is your kind of position, send a resume of your qualifications and a letter of interest.

Simulation Physics, Inc.
41 "B" ST., BURLINGTON, MA 01803

SPI

Noyce, Robert N.: Jul./Aug., 69; expanding markets for solid-state devices;
NUCLEAR; see also Fission; Fusion; REACTORS;
—mining of underground natural gas; Jul./Aug., 6;
—offshore generating stations; Dec., 11;
—orbiting power station; Dec., 55;
—power; pushing beyond environmental and engineering constraints; Feb., 58;
—power plants; see REACTORS;
—warfare and S.A.L.T.; Dec., 44;
—wastes; see WASTES;
—weapons; see Weapons;
Nuclear Power Going to Sea," by Peter Gwynne; Dec., 10;
Nuclear Power Rebellion, The: Citizen vs. Atomic Industrial Establishment; Richard S. Lewis; Jul./Aug., 9;
Nuclear Relief for Natural Gas?" by Peter Gwynne; Jul./Aug., 6;
Nuclear Test Ban Treaty (1963); Jan., 10; and the role of Pugwash (book review);
Nutrition; Jan., 46; alcohol as source of calories; Jan., 62; need for more information of food packaging; Jul./Aug., 75; food additives (book review);

OCEAN; see also Aquaculture;
—dumping of wastes in; new international agreements; Mar./Apr., 70;
— law of the sea; international authority proposed; Oct./Nov., 64;
— Marine Oil Pollution Control; Feb., 13;
— marine traffic control systems; need for federal regulations; Mar./Apr., 52;
—monitoring coastal water quality with ERTS; Ju
—offshore nuclear reactor complexes; Oct./Nov., 10;
—petroleum and mineral exploration from st
continental movement; Dec., 31;
—prehistoric flood on Atlantic floor; Jul./A
—sea-based engineering programs to exp
Jan., 7;
—sea-floor spreading; Dec., 25;
—technologies for undersea explor
—transport; The U.S. Superport C
49;
Oceans: Farming the; Lagging
Hodge; June, 72;
Odum, E. P.; Oct./Nov., 23;
ecosystem responding;
Pesticides; Dec., 4; vs. organic
(correspondence);
Peterson, Esther; Jan., 62; natio
nutritional requirements;
Peterson, Peter G.; Oct./Nov., 6;
Peterson, Robert M.; Jan., 60; pe
Peterson, Russell W.; Mar./Apr., 5
terminal in Delaware Bay;
Petkas, Peter; see Nader, Ra
PETROLEUM; see also Oil;
—Alaskan North Slope re
transport of; Mar./Apr.,
3);
—consensus on don
—exploration and
—high cost of tra
—illusion of "st
June, 63;
—industry; c
Oct./Nov.;
—less res
—oil imp
—poss
(Ge
—se

An Index to Technology Review

Our printer calls Technology Review "the biggest book I've ever seen . . ." That's why you need our annual index. The latest, Volume 75, (1972-73) lists everything from Charles Abels (he wrote us a letter about insect controls) to Alexander Zechella (he described his plan for mass-produced floating nuclear reactors).

Price $2 postpaid (if payment accompanies order). Use the coupon.

To Technology Review, Room E19-430,
Massachusetts Institute of Technology, Cambridge, Mass. 02139

Please send me _____ copies (@ $2, postpaid if payment accompanies order) of the Index to Volume 75 (1972-73) I enclose $_____.

Name _____

Address _____

Please put me on the mailing list to receive future indexes @ $2.00 per index.

An Institute Informant

The Editors' digest of recent and current concerns at the Massachusetts Institute of Technology

Research Notes

Computerized Newspaper Routes

How many trucks are needed to distribute 92,000 newspapers to retailers and newsboys at 550 "drop points"? Where should each truck go, and how many newspapers should it carry?

Studying that question for the *Worcester* (Mass.) *Gazette,* members of M.I.T.'s Sloan School of Management conclude that computerized scheduling and routing of delivery trucks "should be part of the future electronic environment" of newspaper plants. Tentative conclusions from a pilot computerized study: only 13 routes are needed by the *Worcester Gazette,* instead of 20 now used, and vehicles on those routes could be loaded to 67 per cent of their functional capacity instead of the present 50 per cent. The distribution part of the newspaper business turns out to be "very complex," with so many variables that only a computerized approach can take them all into account.

A Pulse of Microwaves

Very brief pulses of 4 billion watts of ten-centimeter microwave radiation have been achieved by Professor George Bekefi in the Research Laboratory of Electronics — another in physicists' long history of converting the energy of accelerated electrons into radiations of various wavelengths. If the pulses can be made longer — the energy bursts are now only 30 billionths of a second long, and therefore contain only small amounts of energy — the new result may be useful for thermonuclear fusion; the present application is to create pulses of infrared radiation by bouncing the microwaves off a "mirror" of high-speed electrons.

A magnetron is the source of radiation in Professor Bekefi's device; capacitors and resonant cavities are used to concentrate the energy for release in the single pulse of very short duration.

Measuring Bone Calcium

A new machine for measuring calcium loss in bones built at M.I.T. and Harvard Medical School is now being tested. As in most such machines, this one measures the absorption by calcium of x-rays beamed through a patient's bone. In this case, measuring the non-absorbed x-rays is accomplished more quickly and accurately than in other medical instruments by techniques borrowed from high-energy physics research — detectors called "multiwire proportional chambers."

Electronic Scales, Laser Thermometer

Four precision strain gauges are arranged as a bridge network in highly sensitive accurate scales built in the Department of Nutrition and Food Science. The purpose is to measure minute weight changes — especially sweat losses — in human metabolic research; the scale — 250 pounds capacity — is so sensitive that it can show the change in a subject's body weight represented by taking one bite from a doughnut.

To measure the temperature of turbulent fluids without disrupting their flow, Professor Michael W. Golay (Department of Nuclear Engineering) has designed a laser thermometer. Light from a single laser is split into two beams, one of which passes through the fluid, the other does not. The extent to which the two beams are out of phase when they are brought together again is a measure of the density of the turbulent fluid — and thus of its temperature. Professor Golay's purpose is to monitor nuclear reactor cooling system temperatures — especially the liquid sodium proposed for fast breeder reactors.

Computer-Based Music

A $92,000 grant from the National Science Foundation will support the Experimental Music Studio, a computer-based facility for creative music composition. With present equipment, music played on an organ keyboard can be displayed in standard music notation on a computer screen; the notes can then be changed, and the computer synthesizes and plays back the changed sounds. Even large, complex scores can be analyzed, synthesized, and printed out as parts for individual players.

The new grant will continue the program, and new equipment and programs will provide composers with better control over digitally synthesized sound, says Barry L. Vercoe, Associate Professor of Music who directs the Studio.

Prospecting on the Moon

When the next U.S. lunar mission (unmanned) orbits the moon in 1980, Thomas B. McCord, Associate Professor of Planetary Physics, will be in charge of experiments to survey the occurrence and distribution of minerals. The principal tool, he says, will be a reflection spectrometer to determine minerals present by the wavelengths of sunlight reflected from the lunar surface. Plans call for a reflectance spectrometer able to measure radiation at 256 wavelengths simultaneously.

If one were to seriously begin prospecting on the moon, one would certainly want to start by flying just such a survey mission," says Professor McCord.

The Effects of Regulation

What are the effects of public regulation on the copper wire industry? Research on this question will be M.I.T.'s part in a National Science Foundation study of federal, state, and local regulation of various industrial sectors. A $310,000 grant to the Center for Policy Alternatives at M.I.T. is part of the $1.6 million N.S.F. program due to end in 1977.

To Grow or Not to Grow

Over 300 Massachusetts cities and towns now have local committees to monitor and recommend state policies on growth and land use — the first state to adopt such a "bottom-up" process, says Lawrence E. Susskind, Associate Professor of Urban Studies and Planning. Now Professor Susskind will use a $20,000 Rockefeller Foundation grant to monitor the success of this "massive local involvement." A team — mostly of graduate students — will ask town officials and leading residents about the process and its effectiveness, including the key question: Did local inputs make any difference in the way the state legislature thinks about land-use and growth management?

Life in the Solar Market

Even though it will provide only half of the hot water for a typical household, there's a good market out there in Massachusetts for a $2,000 solar-powered hot-water heater. And if the price can be brought down to $500, the market will become very lively indeed.

Extrapolating the results of interviews with 79 Massachusetts homeowners, Professor Gary L. Lilien of M.I.T.'s Sloan School of Management concludes that 40,000 solar hot-water-heating units could be sold in the state by 1980 at $2,000 each. If the price were $500, sales would be 72,000. In all of New England, the market for a $500 unit might be as large as 160,000.

Financial motives are not primary in this solar-heater market. Most would-be buyers realize that their money savings are likely to be modest; Professor Lilien thinks most of them would do better over a ten-year period to put their money in a savings bank. But the market he foresees is among "innovative" households — homeowners who are gardeners, who own "economy" cars, who are concerned about conserving resources and want autonomy and simplicity in their lives.

Of Dr. Lilien's interview sample, 79 homeowners were familiar with a test program for subsidized installation and operation of 10-foot solar collectors and hot-water storage systems being conducted by companies associated with the New England Electric System. The 21 neighbors of N.E.E.S. test participants he interviewed were the least enthusiastic of Dr. Lilien's households; that's because, he thinks, they're aware of such disadvantages as unsightly appearance, lack of reliability, need for maintenance, and susceptibility to vandalism.

How to Be Dynamic in An Era of Economies?

Under today's conditions, the challenge to M.I.T. is to solve "a set of simultaneous equations" which represent financial constraints, the need for continuous self-renewal to keep existing programs vital, the need to create new programs in response to new national issues, and the goals of new partnerships, say the President and Chancellor of the Institute in their annual report released early in October.

Financial constraints make creative solutions necessary. For several years, report President Jerome B. Wiesner and Chancellor Paul E. Gray, M.I.T. has experienced "a taut financial climate" which has enforced "stringent" criteria on new programs. The Institute's emphasis has necessarily been on maintaining quality in traditional areas of teaching and research. But they fear that a shortage of "venture capital" has affected more than new ventures; it may in fact "slow down continued development and evolution in every field (and) tend to affect even the most dynamic and promising activities."

Describing other elements in the set of "simultaneous equations," Drs. Wiesner and Gray list among their goals:

— To enable M.I.T. departments and laboratories "to renew themselves at a pace characteristic of the traditions which have made them foremost in their fields."

— To develop throughout M.I.T. "the capacity to focus explicitly on the nature of modern technological society."

— To increase M.I.T.'s interaction with other segments of society, especially industry.

A key national issue puts these goals in jeopardy, say Drs. Wiesner and Gray: Will the U.S. government continue to reimburse universities for the full cost of government-sponsored research? That policy was established in key decisions at the end of World War II, and to it Drs. Wiesner and Gray attribute today's "preeminent position of U.S. science and technology and the leadership of U.S. technical education." Now, as costs increase, there is pressure to limit reimbursement for certain categories of direct research costs and for many indirect costs — a move which threatens "serious disintegration of the research efforts of essentially every major university, including M.I.T."

Measuring Walking

This story begins last summer, when Professor George W. Pratt's daughter complained to him that her horse was lame. Veterinarians were puzzled, and Professor Pratt decided to put his specialty — electrical measurements — to the test. The result is a pair of remarkably large and sensitive "force plates" — aluminum plates 12 by 26 inches with built-in pressure sensors so sensitive that they can record the pulse of a human standing on them.

In the case of his daughter's horse, Professor Pratt's plates were buried in a path and the horse ridden over them; when the forces exerted by two legs were compared, the "favored" leg was instantly revealed — and some clues to the source of the trouble, as well. Professor Pratt's system reveals the full pattern of force exerted on each plate, from initial impact to push-off.

Professor Pratt's plates have now found their way to the Children's Hospital Medical Center, Boston, where they are being used to compare the effects on walking of two different surgical techniques for the repair of hips. Other applications are in view, thinks Professor Pratt. Stand with one foot on each plate and the system displays the sequence of muscle "firings" that you use to maintain your balance — a useful tool, he thinks, for studying neurological disorders.

What's happening in art & architecture...

Science and engineering are being applied in innovative, exciting ways to analyze, preserve, restore, secure, and document art works, buildings, monuments, and antiquities.

Technology & Conservation
is the one magazine devoted to lively coverage of these diverse activities.

Featured in the Winter 1976 issue are articles on: what technical examination of art works reveals, environmental control systems in cultural institutions, neutron activation analysis in analyzing paintings and sculpture and in restoring photographs, architectural/laboratory profile of the new National Air and Space Museum, art registration techniques to thwart thieves...and much more.

Keep current with new developments in art and architecture.

Subscribe to Technology & Conservation

One year subscription (four issues) — $8.00 (North America), $13.00 (overseas) Please enter____ subscriptions

Name_____
Title_____
Company_____
Address_____
City, State, Zip_____

Please make check payable to: The Technology Organization, Inc.
One Emerson Place, Boston, Massachusetts 02114

Management on Video

A videotaped "course" on the management of research and development and the promotion of innovations in the marketplace is now available from M.I.T.'s Center for Advanced Engineering Study. The tapes record six presentations from a recent private seminar for corporate members of M.I.T.'s Industrial Liaison Program by members of the Sloan School of Management and others:

— Ralph Katz, Assistant Professor of Organizational Psychology and Management: "Motivating Scientists and Engineers"

— Eric A. von Hippel, Assistant Professor of Management: "User Needs and Industrial Innovation"

— Edward B. Roberts, Sarnoff Professor of Management: "Technical Venture Strategies"

— Thomas J. Allen, Jr., Professor of Organizational Psychology and Management: "Communication in Science and Technology"

— William H. Gruber, Lecturer in Management: "Corporate Research and Development Interface Management"

— James M. Utterbach, Research Associate, Center for Policy Alternatives: "Innovation in Industrial Organizations."

For further information, call or write Russell Seidel, Center for Advanced Engineering Study, Room 9-230, M.I.T., Cambridge, Mass., 02139 — (617) 253-7444.

Gas from Hot Waste

To a nation running short of natural gas, combustible methane from solid waste is a tempting proposition. An important detail on the way to commercial production has now been added: methane production is doubled and the time required for waste digestion is halved if the process takes place at 65° C. instead of the usual 35° C.

Charles L. Cooney, Associate Professor of Biochemical Engineering, used cultures from sewage effluent, mud, and compost fed with sewage sludge and newsprint (the *New York Times* and the *Boston Globe*, he says).

Classified

PROFESSIONAL

WHEN YOU NEED HELP GETTING HELP

In any technical field, call (215) 735-4908. We have been placing carefully selected engineers, chemists, scientists, metallurgists and technical sales people in all fields since 1959 . . . and we can do the same for you.

No charge unless we fill your position. Over 1000 client companies count on our technical staff for help. You can, too. Call today.

A. L. Krasnow, '51, Pres.

ATOMIC PERSONNEL, INC.
Suite T, 1518 Walnut St., Phila., Pa. 19102
An Employment Agency for All Technical Fields

I SEEK A CHALLENGING POSITION
in corp planning, finance, or marketing. PhD, org chem, MIT, 1969. MBA, finance, U of Delaware, 1976. Small business exp, 3 yrs. US Army, Captain, 2 yrs. Currently, Accounting Instructor, U of DE. Call or write: Ed Kelly, 14 Woodbine Circle, Glen Farms, Newark, DE 19711. (301) 398-6999.

MASS MEDIA INTERN PROGRAM
The American Association for the Advancement of Science announces a program to support up to 18 advanced social and natural science students as intern reporters, researchers, and production assistants in a variety of media for the summer of 1977. Interested students should write: Coordinator, Mass Media Intern Program, AAAS, 1776 Massachusetts Ave., N.W., Washington, D.C. 20036.

RUSSIAN AND GERMAN TRANSLATIONS
Ten years' experience in producing quality translations in all fields of engineering, science, computers, programming, and math. Camera-ready copy. Patrick Spangler ('60). P.O. Box 939, Laguna Beach, CA 92652 (714) 494-1342

WE ARE CONSTANTLY SEARCHING FOR:

- Engineers • Scientists • Programmers
- Systems Analysts • M.B.A.'s

Submit your resume and salary history to:

Martin Lyons
Personnel Services, Inc.
234 No. Main Street
Mansfield, Mass. 02048

PUBLICATIONS

READ LESS/KNOW MORE
All New Advances in Technology
200 Digests per Week of Best Articles from 350 Publications
Qwik-Scan Newsletter Format
SPECIAL 1/2 PRICE OFFER
$12 for 12 weeks
Mail to: **Special Offer Dept.12**
TECHNICAL SURVEY
11001 Cedar Avenue Cleveland OHIO 44106

NAME _____
COMPANY _____
ADDRESS _____
CITY _____

HOW TO EARN MONEY AS A CONSULTANT
(including specimen contracts) $16.
Business Psychology Int'l
2407/13 Pacific Avenue
Virginia Beach, Virginia 23451

HEALTH CARE

Sinus? Phlegm?
Learn what leading ENT specialists recommend. Send 50¢ for "How To" booklet. Hydro Med, Inc., Dept. M, 123 South Swall Street, Los Angeles, California 90048.

SCIENTIFIC MATERIALS

ASTRONOMY MATERIALS
TELESCOPES, 35mm SLIDES, ASTRO GLOBES, SKY CHARTS, BOOKS, PHOTOGRAPHS, MURALS, AUDIO-VISUAL, BINOCULARS, PARTS FOR AMATEUR TELESCOPE MAKERS & MUCH, MUCH MORE!! Your one source for Astronomy Materials. Unique catalog includes discounts on TASCO optical goods. Write for yours today. Enclose 39¢ stamps stating area of interest. MMI CORPORATION, DEPT. TR, 3016 Cresmont Ave., Baltimore, Md. 21211 (301) 366-1222

Classified Ads: $3.00 per line; two-line minimum. (Allow 32 letters & spaces for first line; 50 letters & spaces for each additional line.)

Display Ads: $25.00 for first column inch; $20.00 for each additional inch.

Copy Deadline: one month prior to publication date. Payment in advance of insertion required for less than three insertions in one year. Send orders to Classified Section, *Technology Review*, M.I.T., E19-430, Cambridge, Mass. 02139.

Neustadtl

Continued from page 11

eration a part of our decision," says Dr. Krimsky. Instead, he and the other Board members take the health and well being of the Cantabrigians as their first priority, he says. All the same, "it's an agonizing decision."

Regardless of the Board's final judgment, this effort in local democracy has had far reaching effects. On the negative side, those scientists who firmly believe in the safety of their research are discouraged from the "go slowly and look carefully" attitude the guidelines were meant to inspire. Already their research has been disrupted, and their time lost as they are called to administrate and defend scientific policies and politics.

On the positive side, as Dr. Luria told the Board, "I'm very grateful for all the fuss, because we probably wouldn't have monitored the biohazards so scrupulously without it."

Sara Jane Neustadtl has been a member of the Board of Editors of Technology Review *since 1973.*

INSIGNIA FAVORITES

THE M.I.T. CHAIR. A traditional favorite made of selected northern hardwoods and finished in satiny black with gold trim and gold M.I.T. crest.
In all black or black with cherry arms. each **$75.00**
Red and grey Duraleather Chair Cushion, foam filled. **13.00**

M.I.T. INSIGNIA TIE. A distinctive way to show off the M.I.T. shield. Fine quality polyester with repeat pattern on maroon or navy ground. 4″ wide. **6.95**

M.I.T. GLASSWARE. Fired-on silver Tech crest with chip-resisting platinum rim. Hi-ball, Double Old Fashioned, Single Old Fashioned. each **2.50**

PERSONALIZED PLAQUE. Cast bronze M.I.T. emblem mounted on solid walnut shield or rectangle.
Plaque and bronze plate **24.95**
Engraving $6.00 extra.

DIRECTOR'S CHAIR. Sturdy folding hardwood frame in natural or black finish. Seat and back in heavy white cotton duck with 3-color M.I.T. seal. **33.95**

DIRECTOR'S CHAIR with walnut frame. **41.90**

TR-1975

the Coop

M.I.T. Student Center
84 Massachusetts Avenue
Cambridge, Mass. 02139

Quan.		TOTAL PRICE
___	M.I.T. Chair, cherry arms	Express Collect 75.00 ___
___	M.I.T. Chair, all black	Express Collect 75.00 ___
___	M.I.T. Chair Cushion	13.00 ___
___	M.I.T. Insignia Tie in navy	6.95 ___
___	M.I.T. Insignia Tie in maroon	6.95 ___
___	Hi-ball Glasses	2.50 ___
___	Single Old Fashioned	2.50 ___
___	Double Old Fashioned	2.50 ___
___	Director's Chair ( ) natural, ( ) black	33.95 ___
___	Director's Chair in walnut	41.90 ___
___	Plaque	24.95 ___
___	Engraving	6.00 ___
	( ) Shield, ( ) Rectangle	

Name to be Engraved _____

Class of _____

Please ship to: _____

Street _____ City _____

State _____ Zip _____

Ordered by: _____

Street _____ City _____

State _____ Zip _____

COOP # _____

☐ CHARGE MY ACCOUNT ☐ OR I ENCLOSE REMITTANCE

Mass. Residents: Add 5% sales tax (except ties).
Out-of-state Residents: No tax except when delivered in Mass.
(Make Checks Payable to the Harvard Cooperative Society)

SHIPPING AND HANDLING IN CONTINENTAL UNITED STATES

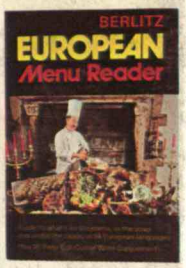
		EAST	MID-WEST	WEST
Director's Chair, Glassware and Plaque	(per order)	1.50	2.50	3.50
M.I.T. Chair Cushion	(per order)	.80	1.20	1.50
M.I.T. Insignia Tie	(per order)	.60	.60	.60

M.I.T. Chairs: Shipped Express Collect from Gardner, Mass.
Please allow approximately 4 weeks for delivery.

ALL PRICES SUBJECT TO CHANGE WITHOUT NOTICE

FREE! if you order a course now! . . .

A copy of the New Berlitz European Menu Reader, just published at $2.95.



A unique dictionary for the person who wants to know what he's ordering and eating.

More than 300 pages. Not a simple translation, but a comprehensive directory of what's in the soup and under the sauce in 14 different languages. The European Menu Reader slips easily into pocket or purse—is indispensable on a trip (or even when dining out locally).

Contains color-indexed, alphabetically arranged sections for the following cuisines: Danish, Dutch, Finnish, French, German, Greek, Italian, Norwegian, Polish, Portuguese, Russian, Serbo-Croatian, Spanish and Swedish.

Complete with special 16-page full-color supplement on European wines and vineyard area maps.

What would you give to learn a second language? (Try $85.) And what's it worth to your company?

There's a premium being paid for language-knowledge in America today—and it's not only in the export trade. In multi-national companies, in major cities, even on the factory floor, a second language marks you as the potential spokesman, the well-educated leader, the man to ask about foreign ways.

And travel is so much more fun when you can meet people and talk their language. Now you can. Easily. Painlessly. All thanks to this 50-lesson do-it-yourself Berlitz® language course. Available in French, German, Italian or Spanish—it's yours for only $85.00.

MAIL-PHONE COUPON

Berlitz Publications, Inc., Dept. 20011
4500 N.W. 135th St., Miami, Florida 33059

YES! Send me your Berlitz Comprehensive Cassette Course today at $85.00 each, plus $2.00 each to cover postage and handling.

☐ French 96100 ☐ German 96101 ☐ Italian 96102 ☐ Spanish 96103

Plus, send me my copy of the new European Menu Reader FREE!

Please print name and address clearly

Name_____

Address_____

City_____ State_____ Zip_____

Please check method of payment:

☐ Check or money order—payable to Berlitz Publications, Inc.
☐ American Express ☐ Carte Blanche
☐ BankAmericard ☐ Diners Club ☐ Master Charge

Credit Card No._____

Expiration Date_____

Interbank No. Master Charge Only_____
(Located above your name)

Signature_____

Allow 4 to 6 weeks for delivery
New York and Florida residents add sales tax

Packaged solidly in leather-type binding, the Berlitz Comprehensive Cassette Course contains:

1. Ten introductory lessons in a 90-minute long first cassette to familiarize you with the spoken language.
2. Forty additional lessons on five convenient 60-minute cassettes, making a total of 6½ hours of recorded instruction in all.
3. 6 illustrated workbooks to use with the tapes, each containing 50 pages of easy-to-understand, concise information to help you speak with the least difficulty. 300 pages, in all, to get you on the way to fluency in a second language.
4. A specially prepared, easy-to-use Rotary Verb Finder will help you with irregular verb forms—once you're ready for grammar.

This course avoids the dry and the dull—mixes voices, sound effects and useful text in the delightful manner only Berlitz, the world's best known language instructor, can offer. And cassettes don't scratch, don't warp and don't unwind—last almost indefinitely. Best of all, they are easy to stick in your pocket, take along on a trip or use in the car.

Prepare yourself for a rewarding future. At the same time, enjoy the social advantages only a second language can bring. For $85.00, choose the course you need to start talking like a native. Use the coupon and order today.

MONEY BACK GUARANTEE Try this Berlitz course for ten days. If you are not satisfied for any reason, simply return it, and obtain a complete refund. You take no risk, so order today.

Want fast service? Pick up the phone (our expense) and Dial 800-327-8351 (Florida Residents Dial 800-432-7521)

Our operator can take your order—even on a credit card—and expedite your instructions. Why not give us a ring—right now!